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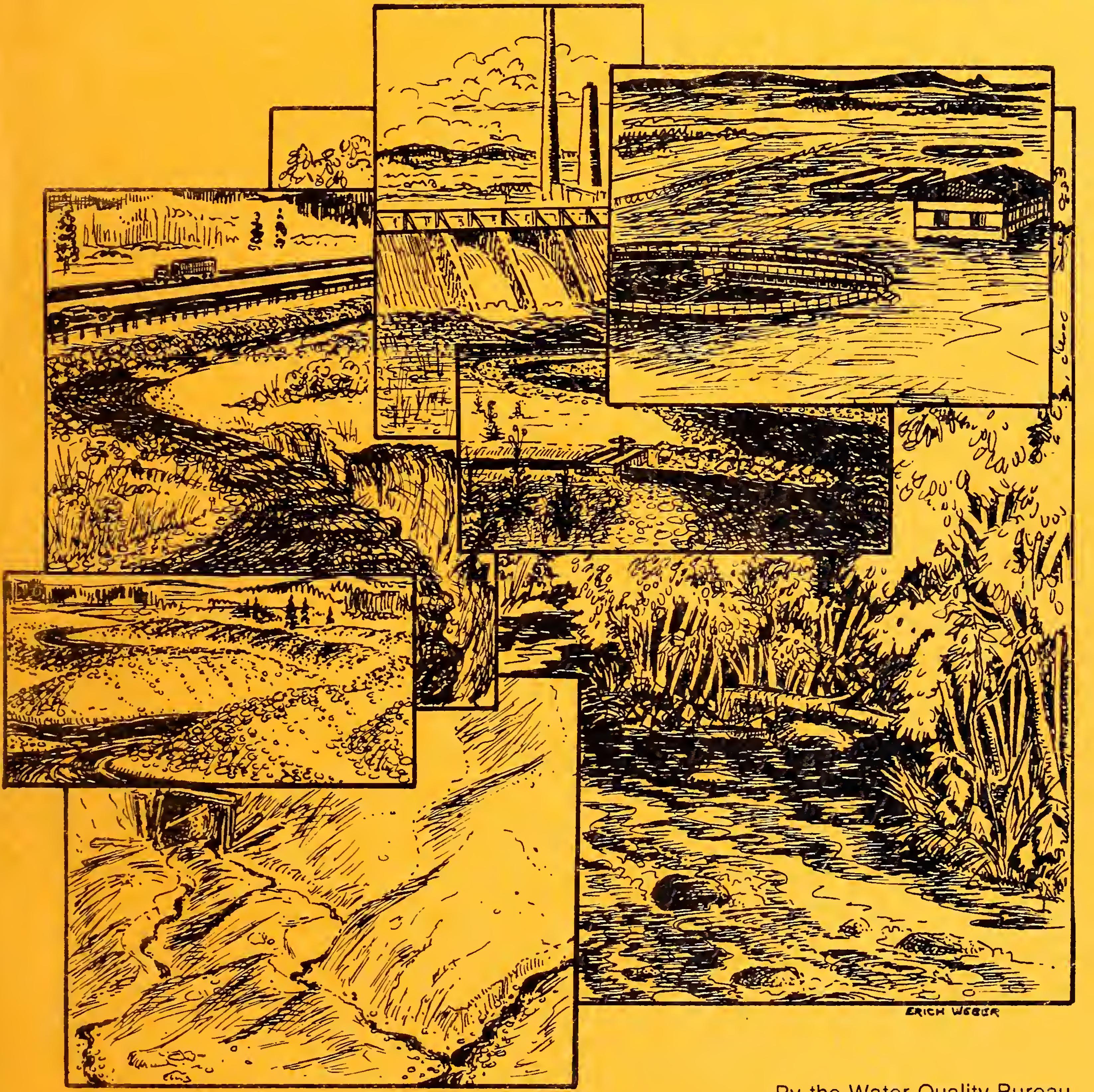

By the Water Quality Bureau

Department of Health and Environmental Sciences

July 1981

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Prickly Pear Creek

A report on man's debilitating impacts

for use by the Prickly Pear Task Force

July 1981

By the Water Quality Bureau
Department of Health and Environmental Sciences

Edited by Charles Wood

Graphics by Erich Weber and Charles Wood

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Welcome to the Prickly Pear...

To look at it from the highway, you'd never know that the Prickly Pear Creek near Helena is one of Montana's poorest-quality streams. It's deceptive. As it flows nearly 40 miles from the Elkhorn Mountains northward past Helena and into Lake Helena, an arm of the Missouri River system, the Prickly Pear appears to be another clean, swift Rocky Mountain trout stream. But this report shows otherwise.

The pollution is man-caused. It began back in 1864 when miners first showed up to exploit the creek and its valley. Then came roads, ranches, cities and factories. By the late 1970s, a biological survey by the state Water Quality Bureau showed what an awful little creek it had become, at least in the sense of the habitat it provided for aquatic life. The evidence pointed to a once-pristine stream that would, if things continued to worsen, be of little use to anything or anyone.

In 1979 and 1980, investigative work was stepped up on the Prickly Pear. The data that was collected and their meanings are presented in this report, which is divided into six parts:

I. A water-quality overview which will show that the water itself, although varying from stretch to stretch, is quite polluted. Specific pollutants and their sources will be discussed.

II. A physical-features inventory which will show the conditions of the streambank (in many spots, bad), the reasons for these conditions, and where sediment is getting into the stream.

III. A detailed look at the Spring Creek drainage, the tributaries from which a great deal of mine acid and sediment come.

IV. The impacts of industrial facilities with a history of their discharges and a look at what's being done to control them.

V. A close look at the impact of the Helena sewage-treatment plant which is pouring pollutants into the lower Prickly Pear.

VI. Some possible solutions to a chronic dewatering problem in the creek below East Helena.

It is hoped that the conclusions and recommendations provided in each of the six sections will be used by the newly-formed Prickly Pear Task Force, a group of 11 citizens representing the many users of the creek. The information should help provide the task force with a sense of direction and priorities in their task of restoring the Prickly Pear to a more natural, "cleaner," more stable condition -- one that will encourage many beneficial uses to be carried out in a more proper, gracious manner than man has in the past 117 years.

It is the premise of the Water Quality Bureau -- in its efforts to protect and improve the quality of waters across Montana -- that if the users of a stream can't clean it up, nobody can.

But before we go on. . .

. . .we must admit that the record flood that struck the Prickly Pear drainage in May 1981, after all of the surveys for this report were in, has made some drastic changes in the creek and some of the tributaries that are not reflected in this report. Most of the changes were in the creek's physical features, outdating some of Part II of the report, our streambank physical features inventory. Part II still stands as a good indicator of where the streambank problems are occurring, and why. And the flood -- wreaking the most damage in what our report already identified as vulnerable, altered areas while doing the least damage in what we saw as the most stable, most "natural" areas -- actually confirmed some of our conclusions.

However, the Water Quality Bureau plans to take another look at the creek's physical features soon to document those changes.

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Part I

A Water Quality Overview
1979-1980

Water Quality Bureau

Department of Health & Environmental Sciences

June 1981

Contact person: Loren Bahls, 449-2406

Introduction

This is the first of six parts in this report that address water-quality problems in Prickly Pear Creek. As an overview, it identifies only the most serious trouble spots and describes in general terms the nature and severity of water-quality degradation originating from the few principal sources of pollution. The remaining parts of this report describe these and other pollution sources at a level of detail sufficient to make specific recommendations for their correction.

Study design

Twelve water-quality monitoring stations were positioned along Prickly Pear Creek from its headwaters to near its mouth, including four stations on significant tributary streams (Table 1).

Each of the 10 upper stations were monitored quarterly in February, June, August and November 1979. Additional samples were taken in April and/or May of 1980 to document water quality during peak flows resulting from snowmelt runoff. The East Helena and Mountain View stations were sampled monthly from January 1979 through January 1980 (excluding March and July 1979) and again in May 1980.

Unfortunately for the purposes of this water-quality study, normal peak flows did not materialize in the spring of 1980. Nevertheless, historical water-quality data are available at certain sites along the stream for periods of normal to above normal peak streamflow. These data will be referenced as appropriate to supplement the data base and to reinforce interpretations and conclusions.

Parameters and water uses

Streamflow plus about 30 water-quality parameters were measured for each site and visit.

About one-half of the measured parameters are not significant as pollutants, and will not be covered in this report; yet they do serve important auxiliary functions: Certain parameters are used to determine a stream's sensitivity to various forms of pollution. For example, the toxicity of some heavy metals to aquatic life is inversely related to the water's hardness. Hardness levels in the Prickly Pear Creek system vary considerably, thus a knowledge of this parameter at the time of sampling is essential for evaluating heavy-metal impact. Other parameters, like conductivity, are useful mainly as indicators of mining-related pollution. Still other parameters, like potassium, are used to establish an ionic balance and check the overall accuracy of the chemical analysis.

Thirteen parameters, including two biological measurements of water quality, were selected for coverage in this part of the report. Seven of these parameters -- turbidity, arsenic, lead, manganese, iron, nitrogen and phosphorus -- address matters of public health and aesthetics. The remaining six parameters -- suspended sediment, ammonia, copper, zinc, diatom diversity and macroinvertebrate diversity -- address the integrity of the stream's biological community, particularly its fish life.

Parameters that affect public health and aesthetics also affect fish and aquatic life, and conversely. Hence, these two categories are not mutually exclusive, but rather group parameters by the beneficial uses that would be first and most severely

TABLE 1 Water-quality monitoring stations along Prickly Pear Creek, 1979-1980

No.	Location	Township	Range	Section
1	Prickly Pear Cr. above Spring Cr. (also above Beavertown & Golconda Creeks)	07N	03W	08DCC
2	Spring Cr. near mouth at Jefferson City	07N	03W	06ACA
3	Prickly Pear Cr. below Spring Cr. (at Interstate-15 rest area)	08N	03W	32BAB
4	Warm Springs Cr. near mouth at Alhambra	08N	03W	16ABB
5	Prickly Pear Cr. below Warm Springs Cr.	08N	03W	16ABB
6	Clancy Cr. near mouth at Clancy	08N	03W	09ABA
7	Prickly Pear Cr. below Clancy Cr.	08N	03W	04DCD
8	Lump Gulch Cr. near mouth (at Marks Ranch)	08N	03W	04ADD
9	Prickly Pear Cr. below Lump Gulch Cr.	08N	03W	03BBA
10	Prickly Pear Cr. at Montana City	09N	03W	13BAD
11	Prickly Pear Cr. at East Helena (below Asarco)	10N	03W	25DCD
12	Prickly Pear Cr. at Mountain View School (below Helena sewage-treatment plant)	10N	03W	03BBA

impaired should pollution occur. For example, arsenic is toxic both to people and to freshwater aquatic life. The criterion for freshwater aquatic life is 440 micrograms per liter (ug/l), but the drinking-water criterion is only 50 ug/l, hence this latter use would be first and most seriously impacted should arsenic levels increase.

As another example, excess concentrations of the plant nutrients nitrogen and phosphorus may generate unsightly growths of algae, which in turn may cause taste and odor problems in water supplies. On the other hand, respiration from large plant masses may, under certain conditions, significantly deplete the ample dissolved oxygen supplies required for maintaining a cold-water fishery. Hence, nitrogen and phosphorus will affect both categories of use.

Some beneficial uses, such as drinking water, are addressed even though they are not now being exercised on Prickly Pear Creek. The report, therefore, addresses potential as well as existing beneficial uses. In other words, we are disregarding for the moment Prickly Pear's existing classifications[1] and beneficial uses and assuming the stream could and should be greatly improved; and we are comparing the creek's existing water quality with certain public-health criteria to show how much it would have to be improved before it would be considered potable. One also should keep in mind that Prickly Pear Creek is part of a greater hydrological system and that its waters may influence downstream uses along the Missouri River.

The chronic dewatering problem known to afflict a section of Prickly Pear Creek in the Helena Valley is not assessed directly in this part of the report. Nevertheless, a lower summertime dilution capacity for the Helena sewage treatment plant (STP) discharge will inflate toxic ammonia concentrations and worsen biological problems at the Mountain View School station. Dewatering will be the subject of Parts II and VI in this series.

Fecal coliform bacteria, of interest with regard to the Helena STP discharge and other possible sources of fecal contamination, were not measured during this phase of the study because of logistic constraints. However, they were monitored during the Helena STP investigation (Part V). Similarly, bedload sediment transport, a phenomenon of significance to benthic biological communities and in the maintenance of irrigation structures, was not measured directly but will be addressed in the reports on the streambank inventory, Spring Creek, and Asarco (Parts II, III and IV of the overall Prickly Pear Report.

Methods

The collection, handling and analysis of the physical/chemical water-quality samples generally followed "Standard Methods" (APHA et al., 1975) or equivalent EPA-sanctioned procedures (USEPA, 1976a; USEPA, 1979). One exception was the procedure used for analysis of heavy metals (arsenic, copper, lead, zinc). The "total recoverable" method used by the Department of Health and Environmental Sciences chemistry laboratory is a bottle-digestion procedure whereby the sample is field acidified and no further acid is added in the laboratory. In contrast, the EPA total recoverable method -- the one on which recent toxics criteria were based -- involves additional acidification and heating prior to analysis. Therefore, the heavy metals data presented in this report probably underestimate those levels that would be produced by the more rigorous standard-digestion procedure.

---

[1] Existing water-use classifications for Prickly Pear Creek and its tributaries are presented in Appendix A.

Methods used to collect and analyze samples of the benthic biological communities generally followed those recommended by the U.S. Environmental Protection Agency (Weber, 1973; Hornig and Pollard, 1978).

To enhance utility, the results of this investigation will be grouped categorically as follows:

- Parameters affecting public health and aesthetics
- Parameters affecting the integrity of the stream's biological community

Each parameter will be treated in a uniform manner, as follows:

- Rationale. These sections include published criteria for protecting beneficial uses and the implications of exceeding those criteria.
- Results. Data will be presented for each station in both tabular and graphical format. Data tables will give minimum, maximum and mean values at each station as well as the number of criteria "exceedences" recorded during the course of the investigation. The graphical presentation for a parameter will consist of a map of the Prickly Pear drainage on which will be displayed for each station the relative magnitude of the mean value.
- Interpretation. The interpretation sections will attempt to translate water-quality data into effects on beneficial uses. "Severe problem areas" or significant sources of pollution will be identified and the cumulative effects of two or more sources will be assessed. Because of the necessarily limited number of sampling stations and their arrangement along the creek, some relatively minor pollution sources may be overlooked.

Streamflow

Rationale

Rate of flow is an important aspect of any water-quality investigation. Instantaneous discharge measurements, along with measurements of pollutant concentrations, allow for estimates of pollutant loading in terms of weight of pollutant carried by an effluent or stream per unit of elapsed time (e.g., pounds per day). Loading calculations are usually applied to point sources of known quantity and relatively consistent quality (e.g., the Helena sewage treatment plant discharge).

In this overview study of water quality in the Prickly Pear drainage, certain tributary streams -- notably Spring Creek -- may be treated at their mouths as point sources of pollution. Because flow and quality in these tributaries are extremely variable, and to a great extent interdependent, it is particularly important that their measurements go hand-in-hand. At the same time, it is important to determine the volume and quality of relatively clean "dilution" water that is available instream for mitigating the impacts of pollutants discharged by wastewater effluents and polluted tributaries.

Results

Streamflow was measured following procedures approved by the U.S. Geological Survey using appropriate metering devices. Results of those measurements are presented in Table 2.

Interpretation

Mean streamflow generally increased in a downstream direction along the mainstem of Prickly Pear Creek due to additions from tributary streams. Anomalous decreases may be due to underground losses or surface diversions. The rise in mean streamflow between Stations 11 and 12 can be explained primarily by the Helena sewage treatment plant (STP) discharge. Mean discharge from the Helena STP over the course of this study was 5.7 cubic feet per second (cfs), representing about 10 percent of the mean streamflow in Prickly Pear Creek at Mountain View School.

Tributary flows were exceedingly variable in terms of their contribution to combined flow in the mainstem. For example, on May 14, 1980, Spring Creek's contribution to flow in Prickly Pear Creek was only 11 percent. Yet in spite of this low flow percentage, pollutant concentrations in Spring Creek were extremely high and water quality in Prickly Pear Creek was severely degraded. During base-flow periods, when pollutant concentrations in Spring Creek were lower, its contribution to flow in the mainstem was as high as 68 percent. Regardless of flow contributions, pollutant levels in Spring Creek consistently exceeded water-quality criteria and degraded water quality in Prickly Pear Creek for a considerable distance downstream.

TABLE 2 Streamflow (cfs) in Prickly Pear Creek, 1979-1980

No.	Location	Sample size	Minimum value	Mean	Maximum value	Percent tributary contribution[1]
1	Prickly Pear Cr. above Spring Cr.	6	3.0	13.8	35.6	
2	Spring Cr. near mouth	6	2.0	3.6	5.1	18.8 (9.0-68.0)
3	Prickly Pear Cr. below Spring Cr.	6	7.1	19.1	41.2	
4	Warm Springs Cr. near mouth	5	0.8	5.5	19.4	9.2 (1.6-22.8)
5	Prickly Pear Cr. below Warm Spg. Cr.	5	17.5	59.6	95.0	
6	Clancy Cr. near mouth	5	1.9	8.8	21.2	17.7 (9.1-24.4)
7	Prickly Pear Cr. below Clancy Cr.	5	20.5	49.7	91.2	
8	Lump Gulch Cr. near mouth	5	0.4	10.1	29.9	16.6 (1.3-22.0)
9	Prickly Pear Cr. below Lump Gulch	5	19.0	60.8	136.0	
10	Prickly Pear Cr. at Montana City	5	13.9	61.7	141.7	
11	Prickly Pear Cr. at East Helena	10	15.9	49.4	169.6	
12	Prickly Pear Cr. at Mtn. View School	12	24.9	55.7	153.0	

---

[1] Estimates the percent of contribution of tributary streamflow to combined streamflow based on a comparison of mean values. (Figures in parentheses represent the range of individual percentages encountered on all sampling dates.)

Parameters affecting public health and aesthetics

Turbidity

Rationale

Turbidity is a measure of the "cloudiness" of water resulting from small suspended particles. These particles may be either organic, such as sewage, leaf litter or animal waste, or inorganic, such as clay or silt.

Turbidity itself is not a grave hazard in drinking water. However, it may interfere with bacterial disinfection and with the technique used to determine a supply's microbiological purity. An incorrect reading will give a false sense of security when in fact a supply may be dangerously contaminated. Since Prickly Pear Creek is not now used as a community water supply, turbidity and other public health criteria are presented in this report only for purposes of comparison, that is, to show how Prickly Pear Creek water compares to water that is considered to be potable.

Too much turbidity or "cloudiness" in the water also will reduce the amount of sunlight reaching aquatic plant communities on the stream bottom. Turbidity also is visually offensive, whether in a glass of drinking water, a tub of bath water, a lake or stream.

The maximum contaminant level for turbidity in drinking water is 1 turbidity unit (TU) as a monthly average. A higher level not to exceed 5 TU may be allowed if the supplier of water can show that such a level will not interfere with disinfection or with microbiological determinations (USPHS, 1962; DHES, 1977). The 5 TU criterion will be used for comparisons in this report.

These turbidity and other drinking water criteria are for treated or "finished" waters delivered to the tap. Unlike metallic pollutants, arsenic and lead for example, turbidity can be removed readily by conventional treatment. Surface waters in western Montana commonly exceed these turbidity values naturally during spring runoff, at which times treatment is required to deliver a supply of acceptable quality. Persistent turbidity at other times of the year may be a sign of pollution.

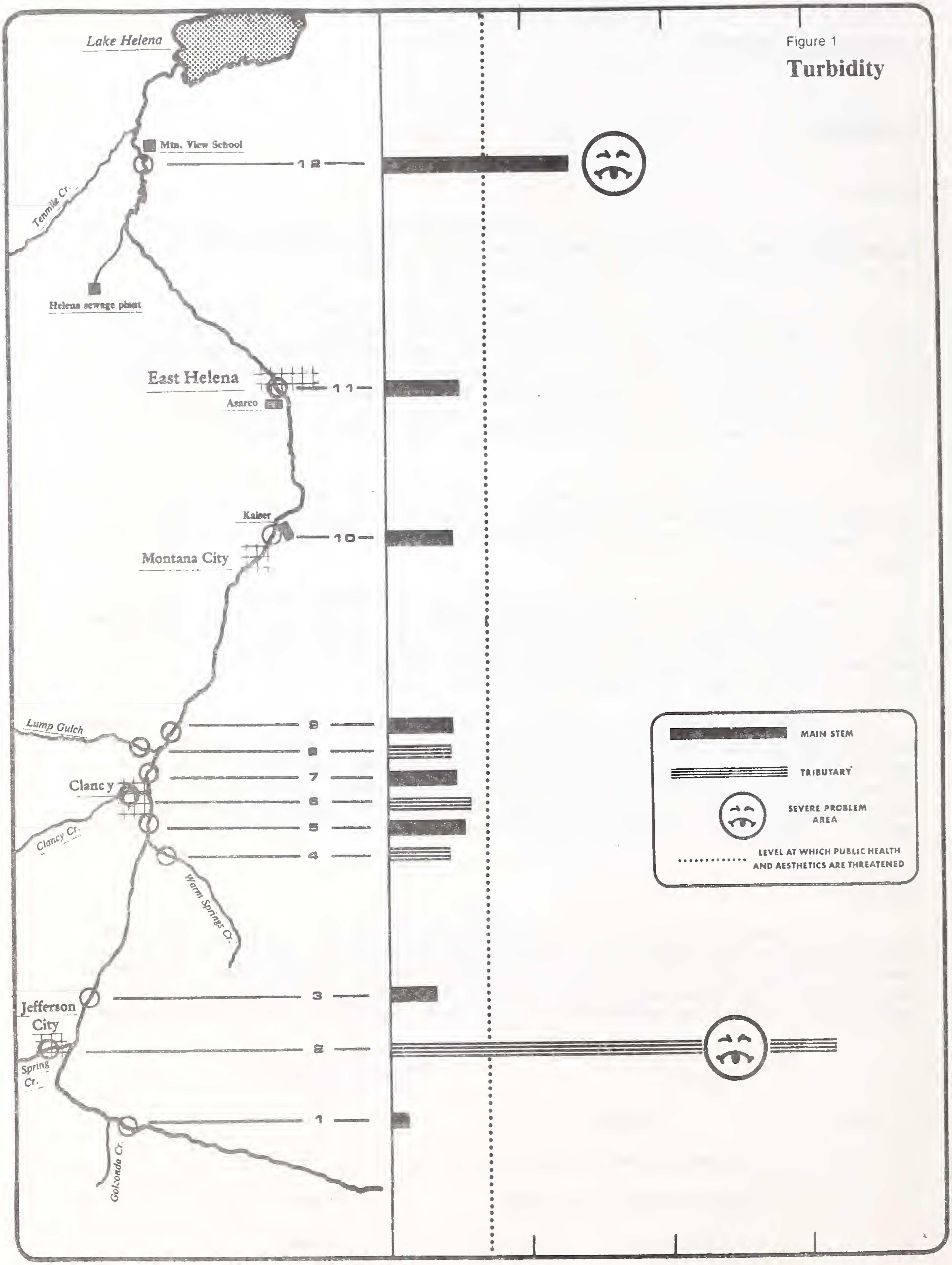
Results

Turbidity results are presented in Figure 1 and Table 3. In addition, the following results will approximate a "worst-case scenario" for Spring Creek and the reach of Prickly Pear Creek immediately downstream from Spring Creek. On May 12, 1975, when Spring Creek discharged an estimated 20 cfs and Prickly Pear Creek above Spring Creek carried an estimated 100 cfs, these turbidity values were recorded:

Station		Turbidity (TU)
No.	Location	
1	Prickly Pear Cr. above Spring Cr.	57
2	Spring Creek near mouth	2500
3	Prickly Pear Cr. below Spring Cr.	1600

Figure 1

Turbidity



These levels at stations 2 and 3 are comparable with those normally found in southeastern Montana's infamous Powder River.

Interpretation

A quick scan of the results reveals two distinct turbidity "hot spots":

- Spring Creek
- Lower Prickly Pear Creek near Mountain View School

The mean turbidity level in Spring Creek is an order of magnitude higher than mean levels in Prickly Pear Creek. All readings in Spring Creek were in excess of the standard. The turbidity problem in Spring Creek is caused by unstable soils, roads, raw gullies, streambanks and tailings left in the wake of mining activity, principally up the Corbin Creek drainage (see Pedersen, 1977 and Part III). The problem in lower Prickly Pear Creek may be due in part to organic turbidity from the Helena STP discharge, but mostly to eroding streambanks and resuspension of sediment particles off the stream bottom (Parts II and V). Some of this resuspended sediment may have originated as far upstream as Spring Creek.

TABLE 3 Turbidity (TU) in Prickly Pear Creek, 1979-1980

No.	Station Location	Sample size	Minimum value	Mean	Maximum value	Number of exceedences[1]
1	Prickly Pear Cr. above Spring Cr.	6	0.3	0.8	1.3	0
2	Spring Cr. near mouth	6	7.8	22.6	61.0	6
3	Prickly Pear Cr. below Spring Cr.	6	1.0	2.3	4.7	0
4	Warm Springs Cr. near mouth	5	0.8	3.0	6.5	1
5	Prickly Pear Cr. below Warm Spg. Cr.	5	1.3	3.8	8.3	1
6	Clancy Cr. near mouth	5	0.9	4.1	10.0	1
7	Prickly Pear Cr. below Clancy Cr.	5	0.7	3.3	8.1	1
8	Lump Gulch Cr. near mouth	5	0.8	3.1	7.0	1
9	Prickly Pear Cr. below Lump Gulch Cr.	5	1.1	3.3	8.6	1
10	Prickly Pear Cr. at Montana City	5	1.0	3.2	8.0	1
11	Prickly Pear Cr. at East Helena	11	0.8	3.6	17.0	2
12	Prickly Pear Cr. at Mtn. View School	11	1.1	9.3	29.0	10

---

[1] Exceedences were based on a criterion of 5 TU for drinking water supplies (USPHS, 1962).

Arsenic

Rationale

Arsenic is a naturally occurring element in rocks, soil, air and living organisms. Compounds of arsenic are relatively insoluble in water, hence natural background levels are very low. Elevated levels of arsenic can result from geothermal activity and overland runoff containing industrial or mine waste or agricultural pesticides. Low pH conditions commonly associated with acid-mine drainage favor the transformation of arsenic to more toxic forms.

The human health criterion for arsenic is 50 ug/l (USPHS, 1962; DHES, 1977). However, a number of studies have shown arsenic to be carcinogenic, hence the ambient water concentrations should be zero, based on the non-threshold assumption for this chemical. Arsenic is relatively less toxic to freshwater aquatic life, for which a criterion of 440 ug/l has been established (USEPA, 1980a). The recommended irrigation and stock watering criteria are 100 ug/l and 200 ug/l, respecively (USEPA, 1973).

Results

Arsenic results are presented in Figure 2 and Table 4.

Interpretation

Two arsenic "hot spots" are evident from the data:

- Spring Creek
- Prickly Pear Creek below East Helena

The elevated arsenic levels in Spring Creek are clearly contributed by mine waste runoff; the maximum value (96 ug/l) was recorded near peak discharge on May 14, 1980. The main source of arsenic in Prickly Pear Creek at East Helena and Mountain View School was the Asarco smelter at East Helena. Just prior to the arsenic exceedences in lower Prickly Pear Creek, two unauthorized discharges were discovered originating from the Asarco facility, carrying 53,750 ug/l and 17,000 ug/l arsenic. When these discharges were first detected and sampled, on November 1, 1979, the arsenic concentration in Prickly Pear Creek immediately below the discharges was 900 ug/l. These discharges have been eliminated (Part IV).

The increase in arsenic concentrations between East Helena and Mountain View School may have been real and caused by one or both of the following: (1) the effluent from the East Helena lagoon, which may receive arsenic-laden wash water from the Asarco facility through the East Helena sewer system; and/or (2) the discharge from the Wilson Ditch, which originates on Asarco property and has been known to carry excessive quantities of arsenic. Or, the increase in arsenic between East Helena and Mountain View School may have been only apparent, caused by unrepresentative sampling at the upstream (East Helena) site. Part IV of this report will elaborate upon the source and status of metals discharges to Prickly Pear Creek in the East Helena area.

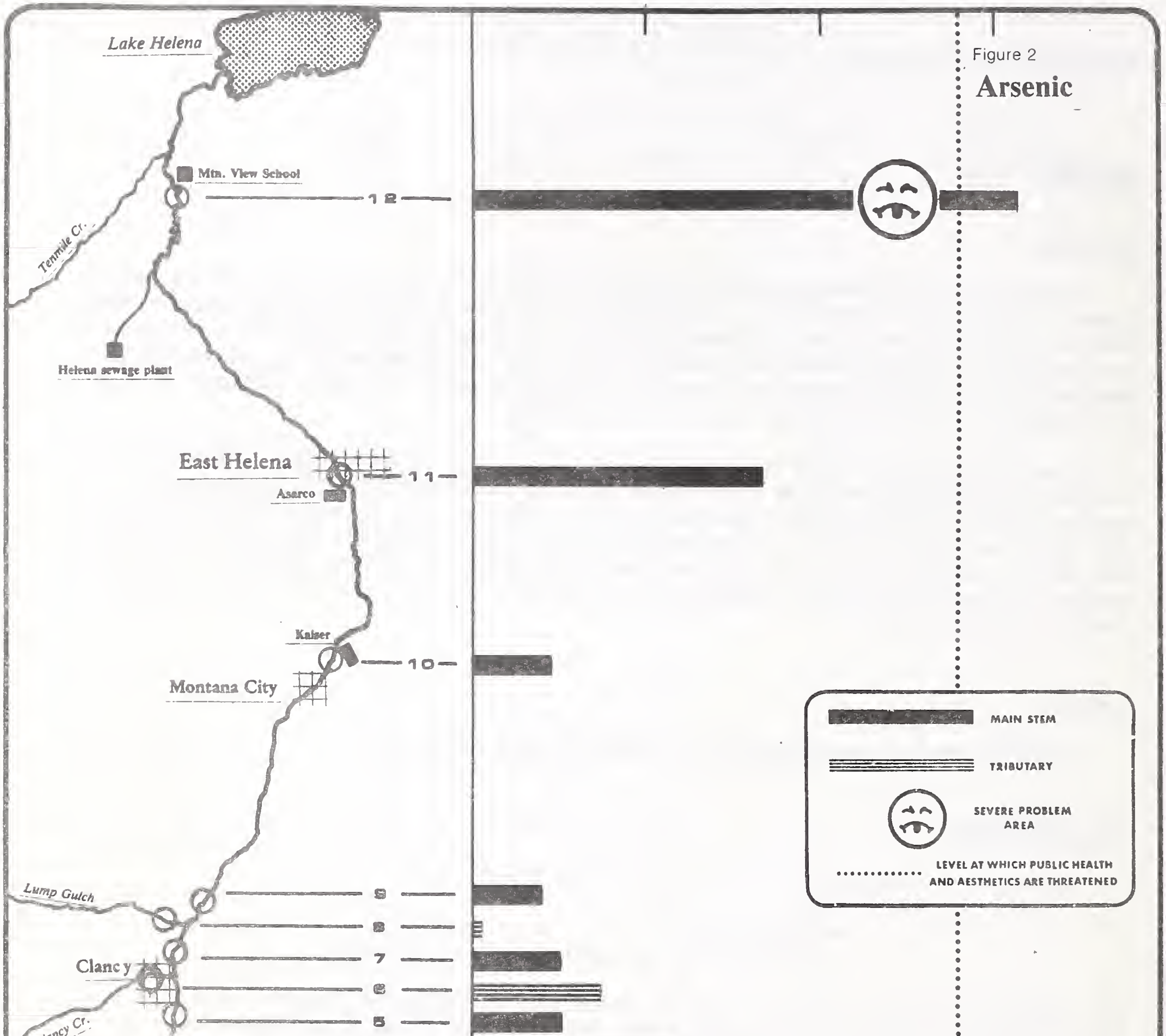


Figure 2

Arsenic

TABLE 4 Total Recoverable Arsenic (ug/l) in Prickly Pear Creek, 1979-1980

No.	Station Location	Sample size	Minimum value[1]	Mean	Maximum value	Number of exceedences[2]
1	Prickly Pear Cr. above Spring Cr.	5	0	0	1	0
2	Spring Cr. near mouth	5	14	44	96	1
3	Prickly Pear Cr. below Spring Cr.	5	3	6	10	0
4	Warm Springs Cr. near mouth	5	12	20	34	0
5	Prickly Pear Cr. below Warm Spg. Cr.	5	6	9	14	0
6	Clancy Cr. near mouth	5	7	13	22	0
7	Prickly Pear Cr. below Clancy Cr.	5	5	9	18	0
8	Lump Gulch Cr. near mouth	5	0	1	3	0
9	Prickly Pear Cr. below Lump Gulch Cr.	5	4	7	13	0
10	Prickly Pear Cr. at Montana City	5	4	8	14	0
11	Prickly Pear Cr. at East Helena	7	9	30	100	1
12	Prickly Pear Cr. at Mtn. View School	8	10	56	260	1

---

[1] Reported laboratory values of <0.001 mg/l (<1 ug/l) are assumed to be zero.

[2] Exceedences were based on a criterion of 50 ug/l for drinking water supplies (USPHS, 1962).

Lead

Rationale

Lead is a soft gray, acid-soluble metal, and is common in various mineral ores combined with sulfate, carbonate or sulfide (galena). The solubility of lead is inversely proportional to pH, thus it is commonly concentrated in acid-mine waters. In addition to their natural occurrence, lead and its compounds may enter and contaminate the environment at any stage during mining, smelting, processing and use (USEPA, 1976b).

The major toxic effects of lead are anemia, nervous disorders and kidney impairment. The drinking water standard to protect human health is 50 ug/l (USPHS, 1962; DHES, 1977). Lead is somewhat less toxic to aquatic life and highly dependent on hardness (USEPA, 1980c). The recommended irrigation and stockwatering criteria for lead are 5,000 ug/l and 100 ug/l, respectively (USEPA, 1973).

Results

Lead results are presented in Figure 3 and Table 5. On May 12, 1975, Spring Creek delivered 25,000 ug/l of lead to upper Prickly Pear Creek, approximating a "worst-case scenario". On that date, lead jumped from less than 20 ug/l above Spring Creek to 20,000 ug/l below Spring Creek. In the course of this study, an unauthorized discharge from the Asarco East Helena facility was found to contain 830 ug/l lead. This discharge has been eliminated.

Interpretation

As with arsenic, the lead "hot spots" are:

- Spring Creek
- Prickly Pear Creek below East Helena

Mine wastes subject to acid-mine drainage account for the lead problem emanating from Spring Creek. The Asarco East Helena facility was the likely source of lead in lower Prickly Pear Creek. As in the case of arsenic, the East Helena lagoon and/or the Wilson Ditch may be discharge points for lead originating at Asarco. One lead value slightly in excess of the criterion was recorded at the mouth of Clancy Creek. None of the lead values recorded during the course of this study exceeded the criterion to protect freshwater aquatic life; however, the stock watering criterion was often exceeded in Spring Creek.

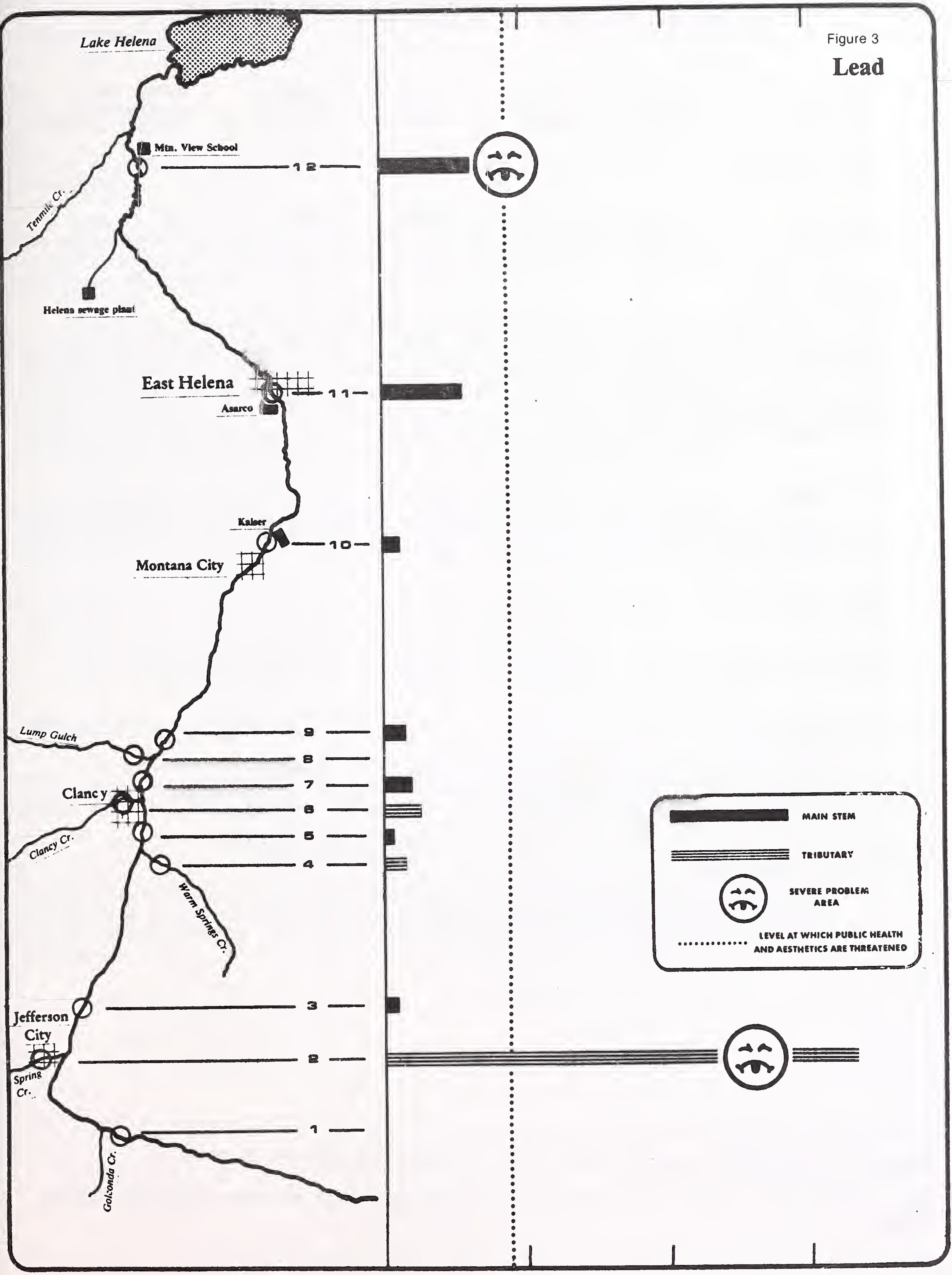


Figure 3

Lead

TABLE 5 Total Recoverable Lead (ug/l) in Prickly Pear Creek, 1979-1980

No.	Station Location	Sample size	Minimum value[1]	Mean	Maximum value	Number of exceedences[2]
1	Prickly Pear Cr. above Spring Cr.	5	0	0	0	0
2	Spring Cr. near mouth	5	60	158	250	5
3	Prickly Pear Cr. below Spring Cr.	5	0	4	14	0
4	Warm Springs Cr. near mouth	5	0	7	36	0
5	Prickly Pear Cr. below Warm Spg. Cr.	5	0	3	8	0
6	Clancy Cr. near mouth	5	0	12	56	1
7	Prickly Pear Cr. below Clancy Cr.	5	0	9	29	0
8	Lump Gulch Cr. near mouth	5	0	0	0	0
9	Prickly Pear Cr. below Lump Gulch Cr.	5	0	7	25	0
10	Prickly Pear Cr. at Montana City	5	0	5	27	0
11	Prickly Pear Cr. at East Helena	7	0	27	70	2
12	Prickly Pear Cr. at Mtn. View School	7	0	30	73	2

---

[1] Reported laboratory values of <0.005 mg/l (<5 ug/l) are assumed to be zero.

[2] Exceedences were based on a criterion of 50 ug/l for drinking water supplies (USPHS, 1962).

Iron

Rationale

Iron is relatively nontoxic to people and freshwater aquatic life, but it is an objectionable constituent in water supplies for either domestic or industrial use. Iron affects the taste of beverages and can stain laundered clothes and plumbing fixtures.

Prime iron pollution sources are industrial wastes, mine drainage waters, and iron-bearing groundwaters. In the presence of dissolved oxygen, iron in mine drainage water is precipitated as ferric hydroxide, which aggregates into a dense flocculant mat on the stream bottom. Commonly known as "yellow boy", this mat can smother bottom-dwelling invertebrates, plants, and incubating fish eggs. With time these flocs can consolidate bottom gravels into pavement-like areas that are unsuitable as spawning sites for nest-building fishes (USEPA, 1976b).

The public welfare criterion to protect domestic water supplies is 0.30 mg/l. The criterion to protect freshwater aquatic life is 1.0 mg/l (USEPA, 1976b). A recommended criterion to protect irrigated soils and crops is 5.0 mg/l (USEPA, 1973).

Results

Iron results are presented in Figure 4 and Table 6.

Interpretation

Iron exceeded the domestic water supply criterion and the freshwater aquatic life criterion at all stations but the uppermost Prickly Pear Creek station. Based on mean concentration, the most extraordinary "hot spot" is:

- Spring Creek

On May 12, 1975, iron at the Spring Creek station measured 76 mg/l, which was nearly four times the maximum value recorded during the course of this study. Yellow boy is commonly observed in Spring Creek and in its polluted tributary, Corbin Creek.

Figure 4

Iron

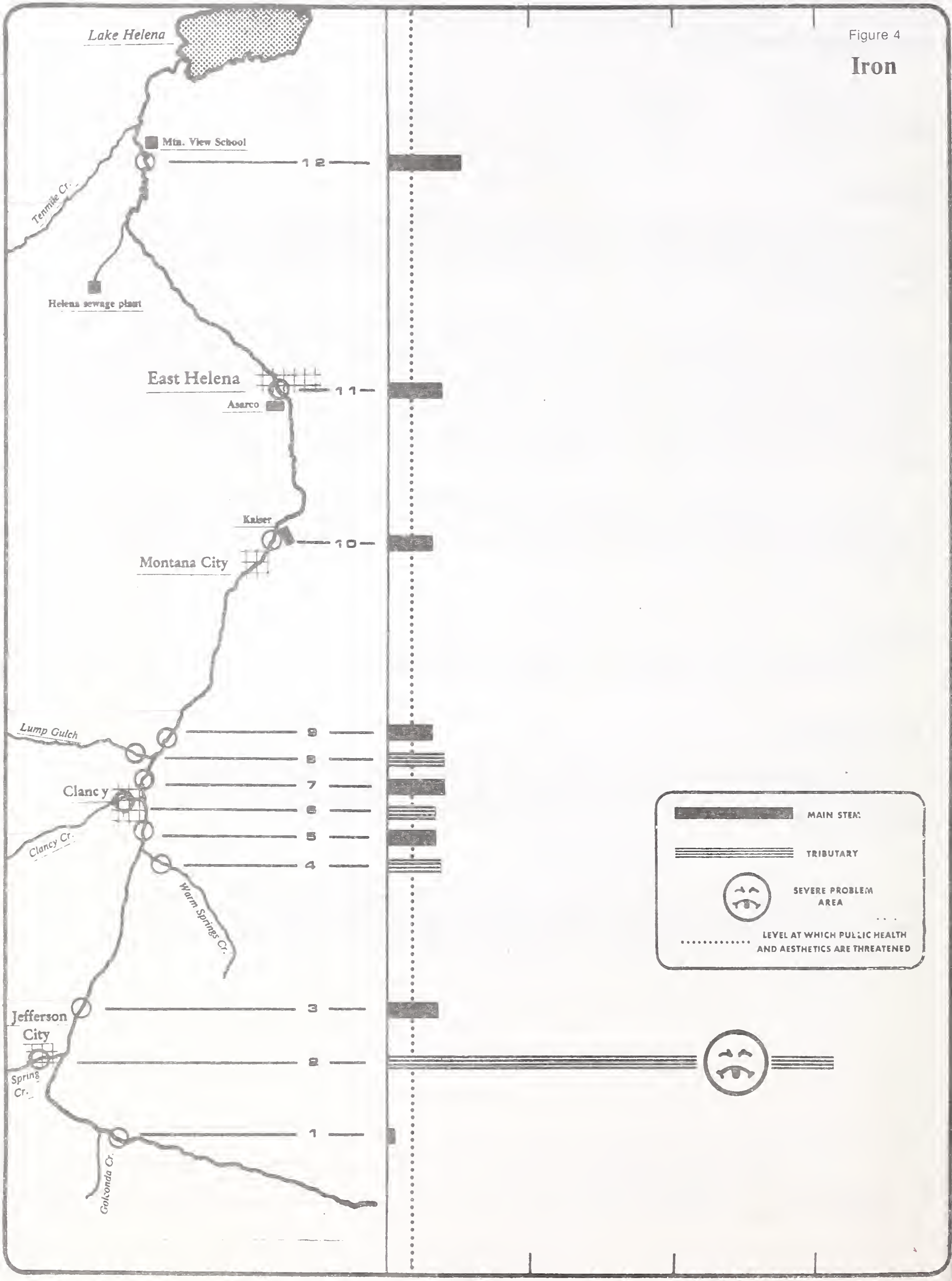


TABLE 6 Total Recoverable Iron (mg/l) in Prickly Pear Creek, 1979-1980

No.	Station Location	Sample size	Minimum value	Mean	Maximum value	Number of exceedences[1]
1	Prickly Pear Cr. above Spring Cr.	6	0.02	0.08	0.22	0
2	Spring Cr. near mouth	6	0.69	5.63	20.70	6
3	Prickly Pear Cr. below Spring Cr.	6	0.05	0.63	2.15	4
4	Warm Springs Cr. near mouth	5	0.12	0.68	2.24	3
5	Prickly Pear Cr. below Warm Spg. Cr.	5	0.21	0.61	1.74	3
6	Clancy Cr. near mouth	5	0.06	0.62	2.02	2
7	Prickly Pear Cr. below Clancy Cr.	5	0.16	0.69	2.47	2
8	Lump Gulch Cr. near mouth	5	0.24	0.70	1.59	4
9	Prickly Pear Cr. below Lump Gulch Cr.	5	0.15	0.54	1.64	3
10	Prickly Pear Cr. at Montana City	5	0.12	0.55	1.70	2
11	Prickly Pear Cr. at East Helena	7	0.10	0.67	2.10	4
12	Prickly Pear Cr. at Mtn. View School	7	0.20	0.89	2.26	5

---

[1] Exceedences were based on a criterion of 0.30 mg/l for domestic water supplies (USEPA, 1976).

Manganese

Rationale

As with iron, manganese may lend a brown stain to laundry and objectionable tastes to beverages. The presence of iron may intensify the adverse effects of manganese. Manganese is relatively nontoxic and generally not considered to be a problem for freshwater aquatic life (USEPA, 1976b). On acid soils, manganese has been found to be toxic to a number of crops at concentrations ranging upward from a few tenths of a milligram per liter (USEPA, 1973).

The domestic water supply criterion for manganese is 0.05 mg/l (USEPA, 1976b). A recommended maximum concentration for manganese in irrigation waters is 0.20 mg/l for continued use on all soils (USEPA, 1973).

Results

Manganese results are presented in Figure 5 and Table 7.

Interpretation

In a pattern very similar to that of iron, manganese exceeded the irrigation water criterion and the domestic water supply criterion at all stations but the uppermost Prickly Pear Creek station. Based on mean concentration, the most extraordinary "hot spot" is:

- Spring Creek

On May 12, 1975, manganese at the Spring Creek station measured 160 mg/l, which was nearly seven times the maximum value recorded during this study and 3200 times the criterion for domestic water supplies.

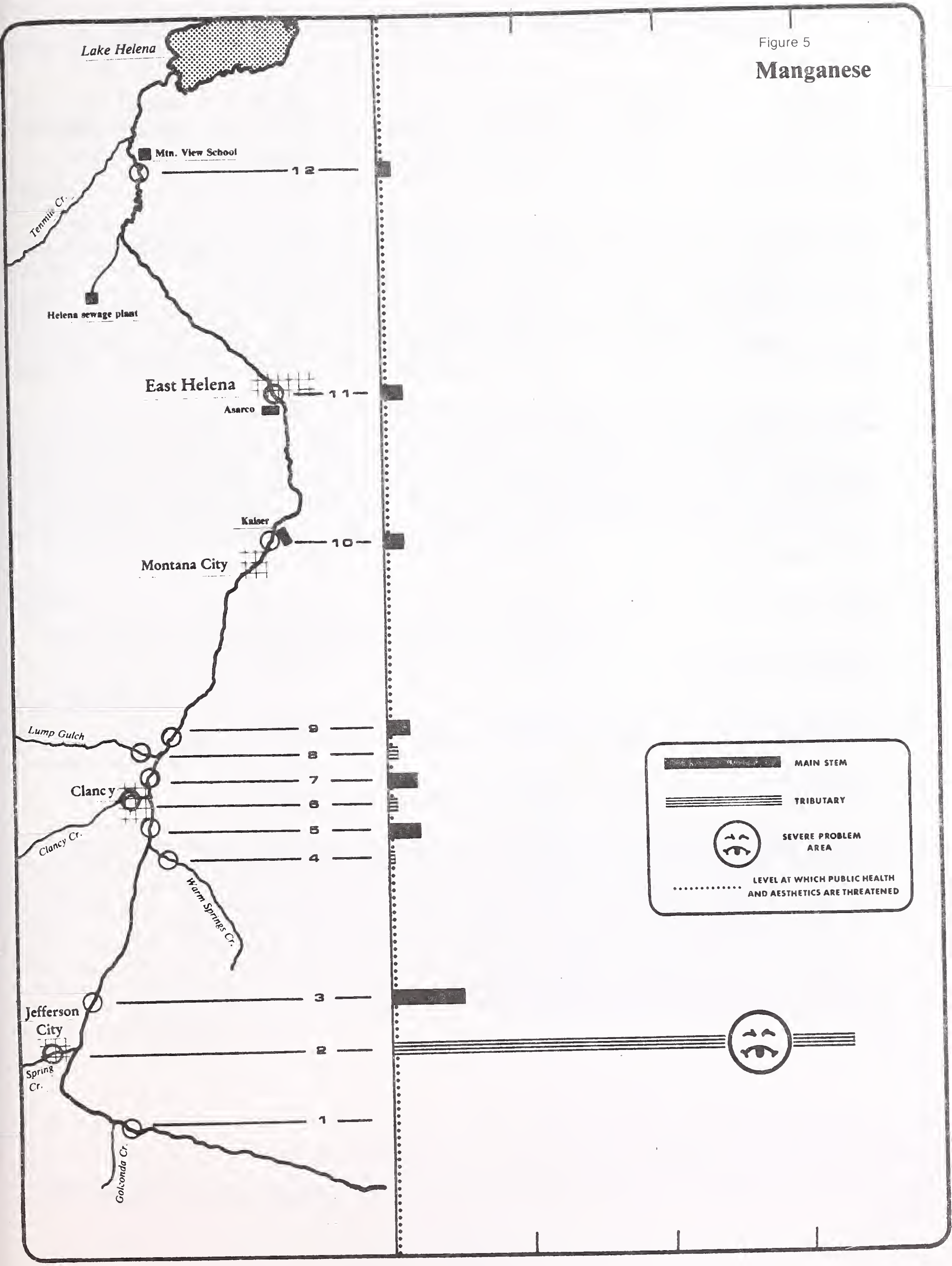


Figure 5

Manganese

TABLE 7 Total Recoverable Manganese (mg/l) in Prickly Pear Creek, 1979-1980

No.	Station Location	Sample size	Minimum value[1]	Mean	Maximum value	Number of exceedences[2]
1	Prickly Pear Cr. above Spring Cr.	6	0.000	0.001	0.005	0
2	Spring Cr. near mouth	6	0.240	6.278	22.900	6
3	Prickly Pear Cr. below Spring Cr.	6	0.020	0.987	2.480	5
4	Warm Springs Cr. near mouth	5	0.020	0.054	0.110	1
5	Prickly Pear Cr. below Warm Spg. Cr.	5	0.150	0.440	1.190	5
6	Clancy Cr. near mouth	5	0.005	0.100	0.230	2
7	Prickly Pear Cr. below Clancy Cr.	5	0.080	0.380	1.070	5
8	Lump Gulch Cr. near mouth	5	0.060	0.138	0.400	5
9	Prickly Pear Cr. below Lump Gulch Cr.	5	0.090	0.304	0.680	5
10	Prickly Pear Cr. at Montana City	5	0.100	0.276	0.650	5
11	Prickly Pear Cr. at East Helena	7	0.070	0.281	0.760	7
12	Prickly Pear Cr. at Mtn. View School	7	0.070	0.223	0.570	7

---

[1] Reported laboratory values of <0.005 mg/l are assumed to be zero.

[2] Exceedences were based on a criterion of 0.050 mg/l for domestic water supplies (USEPA, 1976b).

Nitrogen

Rationale

Although nitrate concentrations in excess of 10 mg/l may cause methemoglobinemia ("blue baby syndrome") in infants, concentrations this high are rarely recorded in surface waters. As an algal nutrient, however, all forms of soluble inorganic nitrogen are active in stimulating plant growth. Nuisance growths of aquatic plants in flowing waters usually can be avoided if total soluble inorganic nitrogen remains below 0.35 mg/l (Muller, 1953). Both nitrogen and phosphorus must be present in sufficient quantities before nuisance growths will develop, hence exceedences for these two elements are considered in tandem.

Nuisance algal growths may look unsightly, snag fishing lines, reduce dissolved oxygen levels at night, and cause taste and odor problems in drinking water supplies. It should be noted that much lower concentrations of nitrogen and phosphorus are required to cause algal "blooms" in lakes and reservoirs than in streams. Hence, the nutrients discharged by Prickly Pear Creek into Missouri River reservoirs (Lake Helena, Hauser Lake, Holter Lake, etc.) will have a much greater algal growth-stimulating effect than they had in Prickly Pear Creek.

Results

Nitrogen results are presented in Figure 6 and Table 8.

Interpretation

In terms of mean concentration and total number of exceedences, the obvious nitrogen "hot spot" is:

- Prickly Pear Creek at Mountain View School

The overwhelming share of nitrogen at this station clearly originates at the Helena sewage treatment plant discharge (see Part V). Lesser quantities may be contributed by the East Helena lagoon and by agricultural and domestic wastes (fugitive fertilizers, manure, household wastewater, etc.) generated in the Helena Valley. Algal growth in this lower reach of Prickly Pear Creek is not excessive simply because the water is usually turbid and abrasive with suspended sediment and the bottom is unstable and therefore unsuitable for attached algae growth. However, the nitrogen discharged to the Missouri River via Lake Helena no doubt stimulates algal growth in downstream reservoirs and worsens taste and odor problems in municipal water supplies served by the Missouri River.

Figure 6

Nitrogen

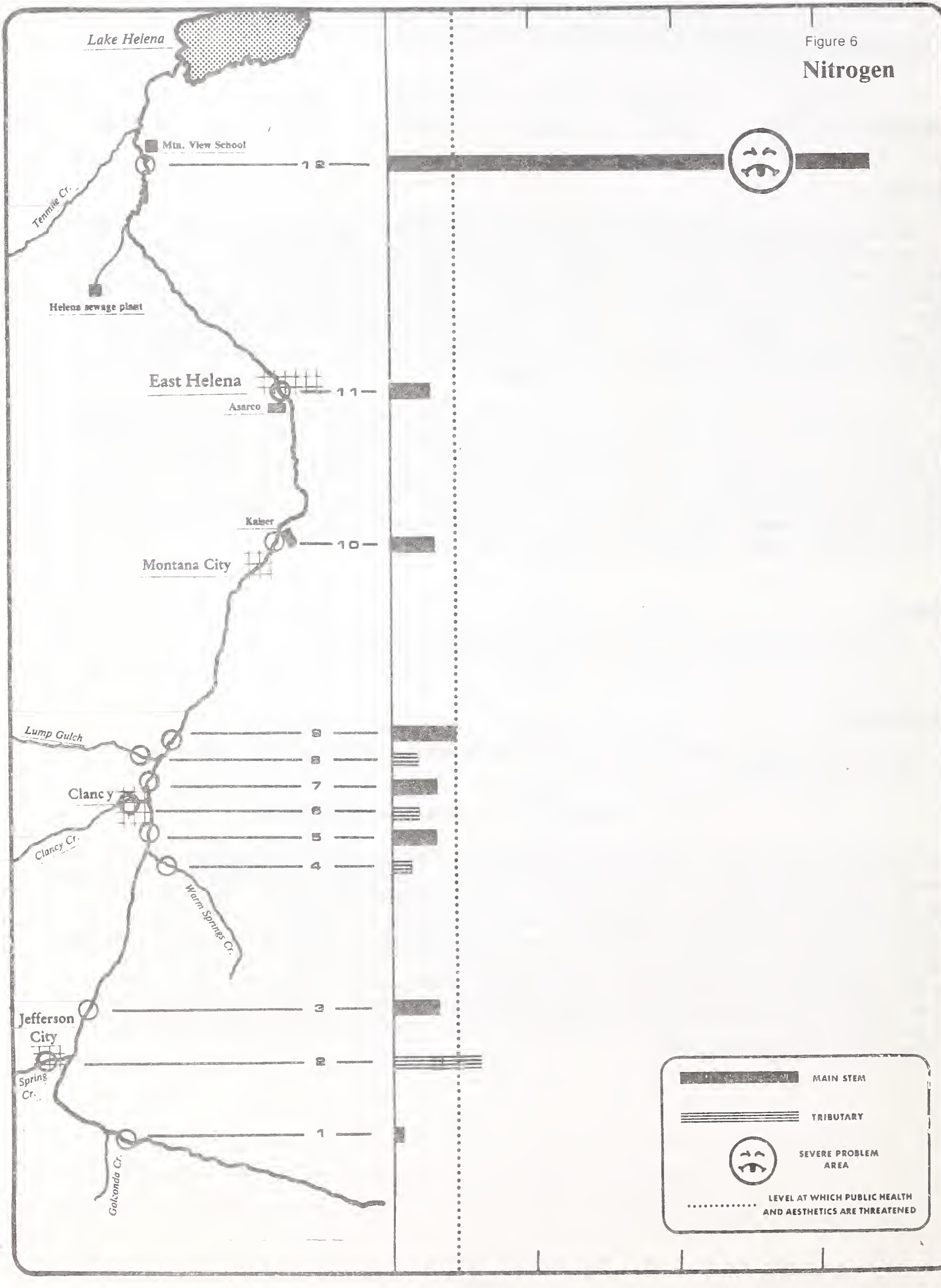


TABLE 8 Total Soluble Inorganic Nitrogen (mg/l $[(NH_3 + NH_4^+) - N + (NO_3^- + NO_2^-) - N]$) in Prickly Pear Creek, 1979-1980

No.	Station Location	Sample size	Minimum value[1]	Mean	Maximum value	Number of exceedences[2]	
						N only	N and P
1	Prickly Pear Cr. above Spring Cr.	5	0.00	0.04	0.08	0	0
2	Spring Cr. near mouth	5	0.31	0.40	0.48	4	2
3	Prickly Pear Cr. below Spring Cr.	5	0.09	0.25	0.42	1	0
4	Warm Springs Cr. near mouth	5	0.05	0.10	0.16	0	0
5	Prickly Pear Cr. below Warm Spg. Cr.	5	0.12	0.24	0.38	1	0
6	Clancy Cr. near mouth	5	0.06	0.17	0.48	1	1
7	Prickly Pear Cr. below Clancy Cr.	5	0.10	0.24	0.36	1	0
8	Lump Gulch Cr. near mouth	5	0.03	0.14	0.25	0	0
9	Prickly Pear Cr. below Lump Gulch Cr.	5	0.08	0.34	0.79	2	0
10	Prickly Pear Cr. at Montana City	6	0.09	0.24	0.36	1	0
11	Prickly Pear Cr. at East Helena	12	0.06	0.21	0.36	1	0
12	Prickly Pear Cr. at Mtn. View School	12	0.49	2.60	4.90	12	12

---

[1] Reported laboratory values of <0.01 mg/l for both nitrate plus nitrite as N and total ammonia as N are recorded here as zero.

[2] Nuisance growths of aquatic plants in streams usually can be avoided if total phosphorus is kept below 0.05 mg/l (Mackenthun, 1969) or if total soluble inorganic nitrogen remains less than 0.35 mg/l (Muller, 1953).

Phosphorus

Rationale

Phosphorus is relatively nontoxic to human and freshwater aquatic life, but it is frequently the single element that limits aquatic plant growth in lakes and streams. As an algal nutrient, nuisance growths of aquatic plants in flowing waters usually can be avoided if total phosphorus is kept below 0.05 mg/l (Mackenthun, 1969). Both nitrogen and phosphorus must be present in sufficient quantities before nuisance growths will develop, hence exceedences for these two elements are considered in tandem.

Nuisance algal growths may look unsightly, snag fishing lines, reduce dissolved oxygen levels at night, and cause taste and odor problems in drinking water supplies. It should be noted that much lower concentrations of phosphorus and nitrogen are required to cause algal "blooms" in lakes and reservoirs than in streams. Hence, the nutrients discharged by Prickly Pear Creek into Missouri River reservoirs (Lake Helena, Hauser Lake, Holter Lake, etc.) will have a much greater algal growth-stimulating effect than they had in Prickly Pear Creek. This could be of significant consequence to downstream water users, for example the City of Great Falls.

Results

Phosphorus results are presented in Figure 7 and Table 9.

Interpretation

In terms of mean concentration and total number of exceedences, the obvious phosphorus "hot spot" is:

- Prickly Pear Creek at Mountain View School

The overwhelming share of phosphorus at this station clearly originates at the Helena sewage treatment plant discharge (see Part V). Lesser quantities may be contributed by the East Helena Lagoon and by agricultural and domestic wastes generated in the Helena Valley. Algal growth in this lower reach of Prickly Pear Creek is not excessive because of cloudy water and an unstable bottom. However, the large quantities of phosphorus and nitrogen discharged together to the Missouri River no doubt stimulate algae growth in downstream reservoirs. Although plant nutrients are occasionally excessive in Spring Creek, algal growth is checked by toxic metals. Higher-than-average nutrient levels in Clancy Creek may be due to residential development with on-site sewage disposal systems.

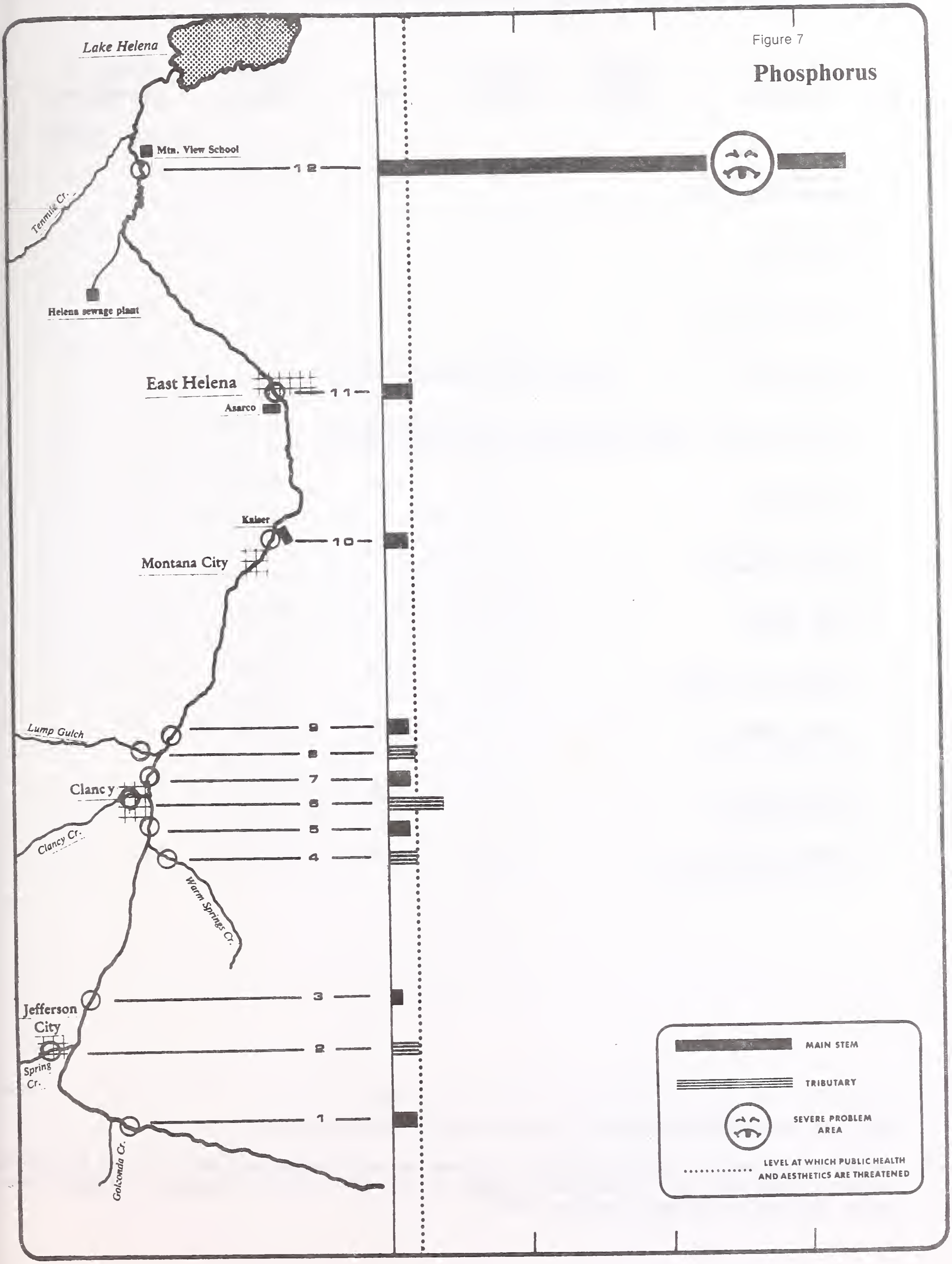


Figure 7

Phosphorus

TABLE 9 Total Phosphorus (mg/l) in Prickly Pear Creek, 1979-1980

No.	Station Location	Sample size	Minimum value[1]	Mean	Maximum value	Number of exceedences[2]	
						P only	N and P
1	Prickly Pear Cr. above Spring Cr.	5	0.00	0.05	0.20	1	0
2	Spring Cr. near mouth	5	0.02	0.05	0.14	2	2
3	Prickly Pear Cr. below Spring Cr.	5	0.01	0.02	0.04	0	0
4	Warm Springs Cr. near mouth	5	0.01	0.05	0.11	3	0
5	Prickly Pear Cr. below Warm Spg. Cr.	5	0.02	0.04	0.06	1	0
6	Clancy Cr. near mouth	5	0.02	0.10	0.16	3	1
7	Prickly Pear Cr. below Clancy Cr.	5	0.02	0.04	0.08	2	0
8	Lump Gulch Cr. near mouth	5	0.01	0.05	0.10	2	0
9	Prickly Pear Cr. below Lump Gulch Cr.	5	0.02	0.04	0.08	2	0
10	Prickly Pear Cr. at Montana City	6	0.01	0.04	0.08	2	0
11	Prickly Pear Cr. at East Helena	12	0.02	0.05	0.12	5	0
12	Prickly Pear Cr. at Mtn. View School	12	0.19	0.86	1.60	12	12

---

[1] Reported laboratory values of <0.01 mg/l are assumed to be zero.

[2] Nuisance growths of aquatic plants in streams usually can be avoided if total phosphorus is kept below 0.05 mg/l (Mackenthun, 1969) or if total soluble inorganic nitrogen remains less than 0.35 mg/l (Muller, 1953).

Parameters affecting fish and other aquatic life

Sediment

Rationale

Inorganic sediment--including clay, sand and silt particles--originates from streambank erosion, placer mining, mine waste dumps, gravel washing, and loose soils from unprotected croplands, highway construction and building projects. Both bedload and suspended sediment adversely affect fisheries by covering the bottom of a stream or lake with a blanket of material that destroys the bottom fauna and the spawning grounds of fish. Sediment also may clog sprinkler nozzles and create maintenance problems with irrigation pumps and headgates.

Good or moderate fisheries can be maintained in waters that normally contain 25 to 80 mg/l suspended solids, but the yield of fish might be lower than in waters containing 25 mg/l or less. Waters normally containing 80 to 400 mg/l suspended solids are unlikely to support good freshwater fisheries (FWPCA, 1968).

Results

Sediment results are presented in Figure 8 and Table 10. In addition, the following results will approximate a "worst-case scenario" for Spring Creek and the reach of Prickly Pear Creek immediately downstream from Spring Creek. On May 12, 1975, when Spring Creek discharged an estimated 20 cfs and Prickly Pear Creek above Spring Creek carried an estimated 100 cfs, these suspended sediment values were recorded:

Station		Suspended Sediment (mg/l)
No.	Location	
1	Prickly Pear Cr. above Spring Cr.	150
2	Spring Cr. near mouth	7830
3	Prickly Pear Cr. below Spring Cr.	4090

Interpretation

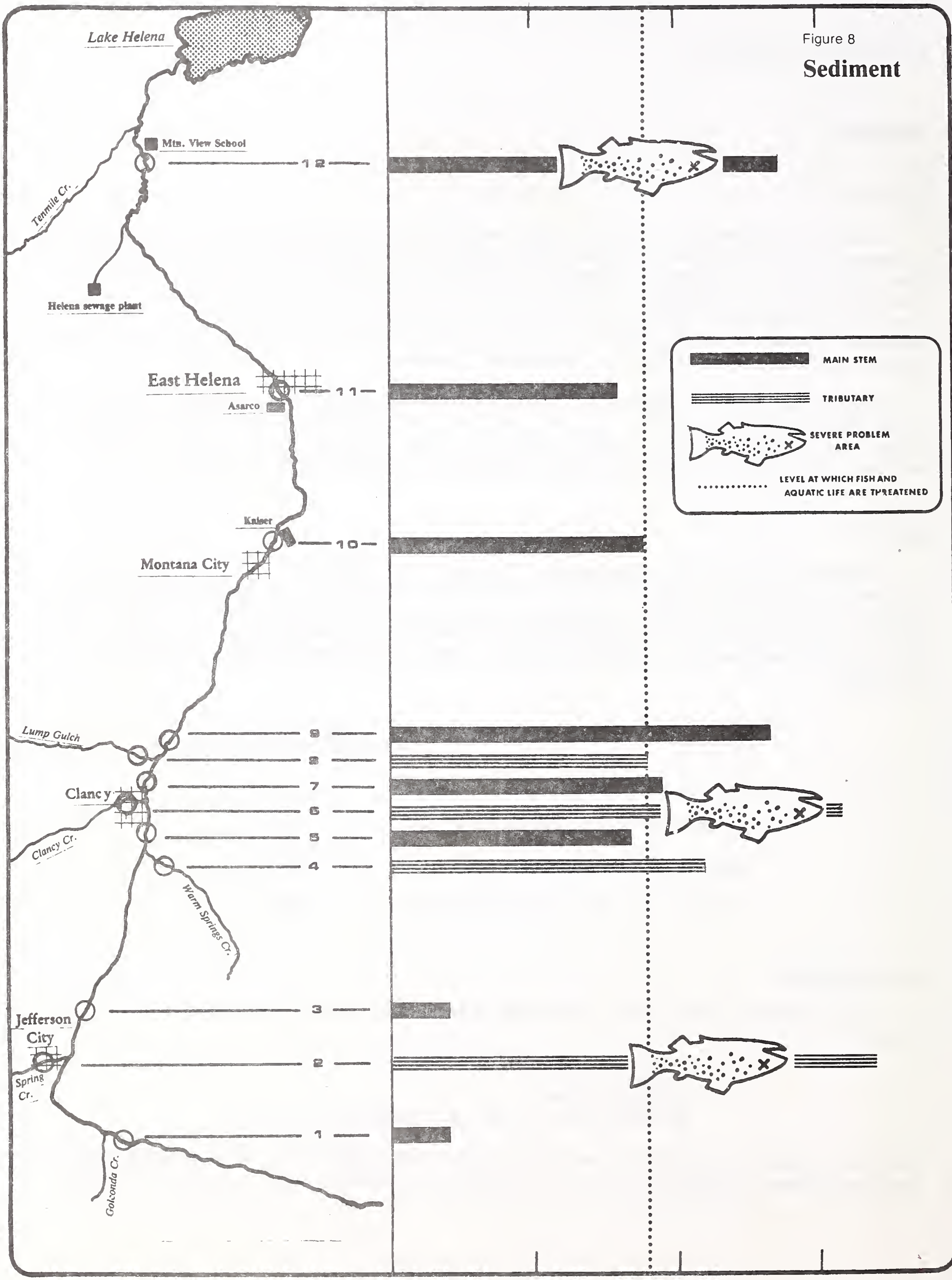
Three sediment "hot spots" are evident from mean values and number of exceedences:

- Spring Creek
- Clancy Creek
- Prickly Pear Creek at Mountain View School

Sediment problems in Spring Creek and Clancy Creek stem mainly from historical hard rock and placer mining activities. Similarly, sediment loads in much of the upper

Figure 8

Sediment



Prickly Pear Creek drainage (from Spring Creek to Montana City) are due in large part to hydrologic instability brought on by old placer workings, highway and railroad placement, and grazing activities. The sediment problem in lower Prickly Pear Creek is due mostly to eroding streambanks and resuspension of fine particles off the stream bottom. In past years, Asarco's practice of flushing sediment from their dam on Prickly Pear Creek during low flows resulted in periodic episodes of severe bedload and suspended sediment pollution from East Helena downstream. One such episode occurred during this study but the practice of untimely sediment releases has been discontinued (see Part IV). Sediment captured behind Asarco's dam and ultimately released downstream may originate from as far upstream as Spring Creek.

TABLE 10 Total Suspended Sediment (mg/l) in Prickly Pear Creek, 1979-1980

No.	Station Location	Sample size	Minimum value	Mean	Maximum value	Number of exceedences[1]	
						25 mg/l	80 mg/l
1	Prickly Pear Cr. above Spring Cr.	6	2.7	5.7	7.2	0	0
2	Spring Cr. near mouth	6	6.1	48.2	97.6	4	2
3	Prickly Pear Cr. below Spring Cr.	6	1.5	5.7	10.2	0	0
4	Warm Springs Cr. near mouth	5	6.0	31.3	106.0	1	1
5	Prickly Pear Cr. below Warm Spg. Cr.	5	5.5	23.7	66.0	1	0
6	Clancy Cr. near mouth	5	6.3	44.9	104.0	2	2
7	Prickly Pear Cr. below Clancy Cr.	5	6.3	27.0	71.0	2	0
8	Lump Gulch Cr. near mouth	5	6.3	25.6	58.2	2	0
9	Prickly Pear Cr. below Lump Gulch Cr.	5	6.3	37.7	83.8	3	1
10	Prickly Pear Cr. at Montana City	5	3.6	25.0	56.2	2	0
11	Prickly Pear Cr. at East Helena	11	4.0	22.7	71.3	4	0
12	Prickly Pear Cr. at Mtn. View School	11	5.7	38.7	86.6	7	2

---

[1] Fisheries can be maintained in waters that contain 25 to 80 mg/l suspended solids, but the yield of fish might be lower than in waters containing 25 mg/l or less. Waters carrying more than 80 mg/l suspended solids are unlikely to support good freshwater fisheries (FWPCA, 1968).

Ammonia

Rationale

Ammonia as a pollutant most commonly originates from the incomplete oxidation of municipal wastewaters. The un-ionized fraction (NH_3) of the total ammonia complement (NH_3 + NH_4^+) is highly toxic to fish and other aquatic life. The relative abundance of the un-ionized component is directly related to the temperature and pH of the water.

For cold water (salmonid) fish, the ammonia criterion is expressed as 0.016 mg/l un-ionized ammonia nitrogen (NH_3-N) (USEPA, 1976b; Thurston et al., 1979).

Results

Ammonia results are presented in Figure 9 and Table 11.

Interpretation

The only ammonia "hot spot" is:

- Prickly Pear Creek at Mountain View School

It is very likely that ammonia is restricting the growth and propagation of fish and other aquatic life in Prickly Pear Creek from the point of entry of the Helena sewage treatment plant discharge downstream to Lake Helena. Together with the dewatering problem, it is the primary reason that this reach of the stream is not recognized as having a fishery potential and is classified as being fit for industrial and agricultural use only (see Appendix A and Part V).

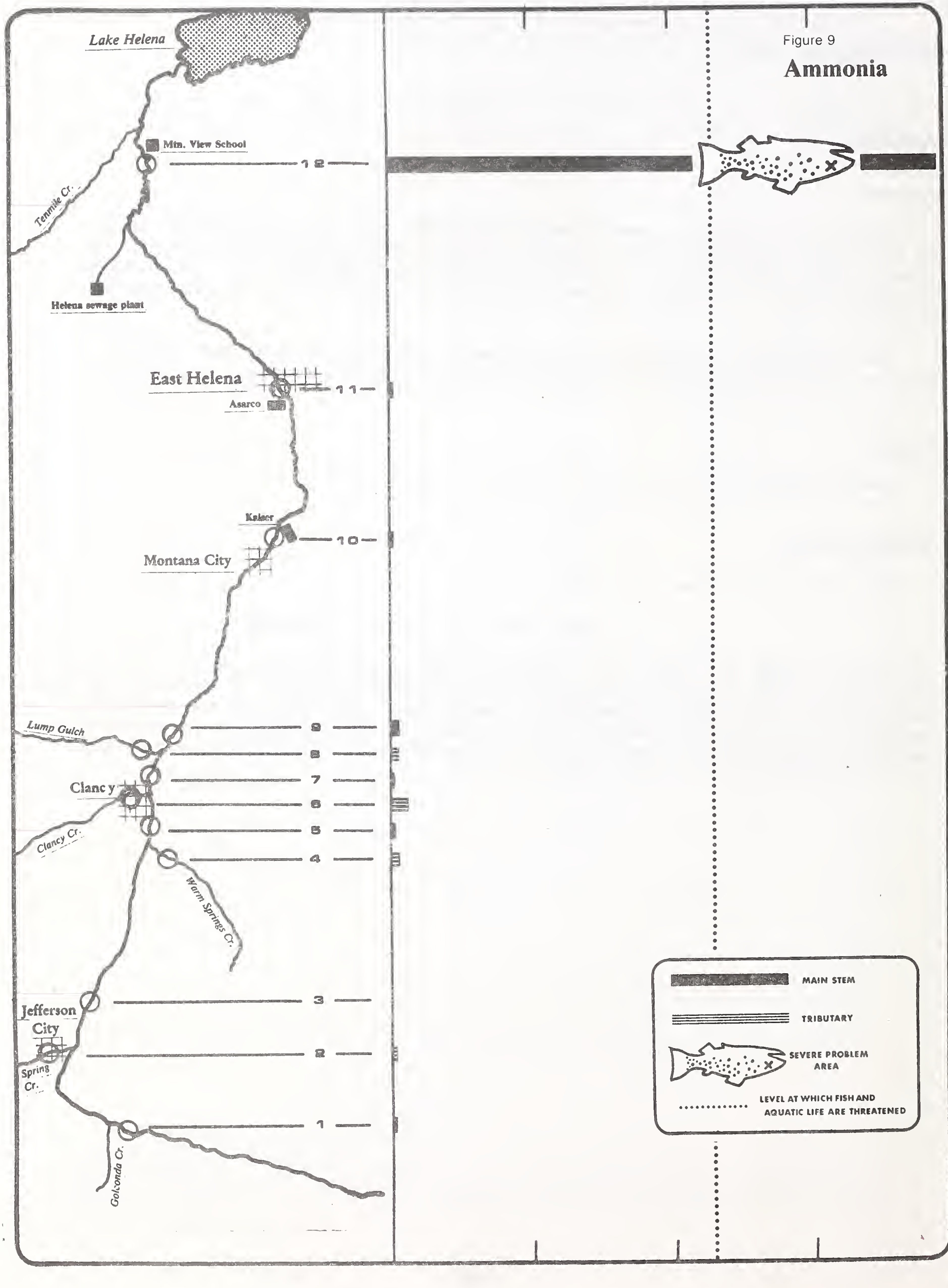


Figure 9

Ammonia

TABLE 11 Total Ammonia (mg/l $NH_3 + NH_4^+$ - N) in Prickly Pear Creek, 1979-1980

No.	Station Location	Sample size	Minimum value	Mean	Maximum value	Number of exceedences[1]
1	Prickly Pear Cr. above Spring Cr.	5	0.00	0.01	0.03	0
2	Spring Cr. near mouth	5	0.00	0.01	0.04	0
3	Prickly Pear Cr. below Spring Cr.	5	0.00	0.00	0.02	0
4	Warm Springs Cr. near mouth	5	0.00	0.02	0.05	0
5	Prickly Pear Cr. below Warm Spg. Cr.	5	0.00	0.01	0.04	0
6	Clancy Cr. near mouth	5	0.00	0.05	0.26	0
7	Prickly Pear Cr. below Clancy Cr.	5	0.00	0.01	0.04	0
8	Lump Gulch Cr. near mouth	5	0.00	0.02	0.05	0
9	Prickly Pear Cr. below Lump Gulch Cr.	5	0.00	0.02	0.11	0
10	Prickly Pear Cr. at Montana City	6	0.00	0.01	0.02	0
11	Prickly Pear Cr. at East Helena	12	0.00	0.01	0.07	0
12	Prickly Pear Cr. at Mtn. View School	12	0.09	1.71	3.30	4

---

[1] Exceedences were based on a criterion of 0.016 mg/l un-ionized ammonia nitrogen (USEPA, 1976b). This criterion is designed to protect cold water fish. Un-ionized ammonia nitrogen (NH_3 - N) was calculated from total ammonia nitrogen ([$NH_3 + NH_4^+$] - N) by applying the appropriate conversion factor from Table 2 in Thurston, et al. (1974).

Copper

Rationale

Copper is a soft heavy metal that is ubiquitous in the rocks and minerals of the earth's crust. In nature, copper occurs usually as sulfides and oxides and occasionally as metallic copper. Weathering and solution of these natural copper minerals results in background levels of copper in natural surface waters of well below 20 ug/l. Higher concentrations of copper usually result from human activities.

Copper is far more toxic to aquatic life, particularly aquatic plant life, than to human beings and other warm-blooded animals. Copper toxicity varies with the water's hardness. As a rule of thumb, copper should not exceed 5.6 ug/l as a 24-hour average concentration in order to assure protection of freshwater aquatic life (USEPA, 1980b).

As a constituent of drinking water, copper imparts an undesirable taste at higher concentrations. A water supply criterion has been set at 1 mg/l (1,000 ug/l) (USPHS, 1962). Recommended maximum concentrations of copper for livestock watering and irrigation are 500 ug/l and 200 ug/l, respectively (USEPA, 1973).

Results

Copper results are presented in Figure 10 and Table 12. On May 12, 1975, Spring Creek delivered 8,000 ug/l of copper to upper Prickly Pear Creek, approximating a "worst case scenario". On that date, copper in Prickly Pear Creek jumped from 70 ug/l immediately above Spring Creek to 4,600 ug/l below Spring Creek. The somewhat elevated upstream value might have been due to runoff from mined areas up Golconda Gulch.

Interpretation

On the basis of mean values and exceedences, only one source contributes appreciably to the copper problem in Prickly Pear Creek:

- Spring Creek

Excessive copper is a product of mine wastes and acid-mine drainage in the Spring Creek watershed (Part III). Excessive copper values and exceedences recorded elsewhere along the mainstem of Prickly Pear Creek represent residual copper derived from Spring Creek, much of it associated with bedload and suspended sediment particles.

Figure 10

Copper

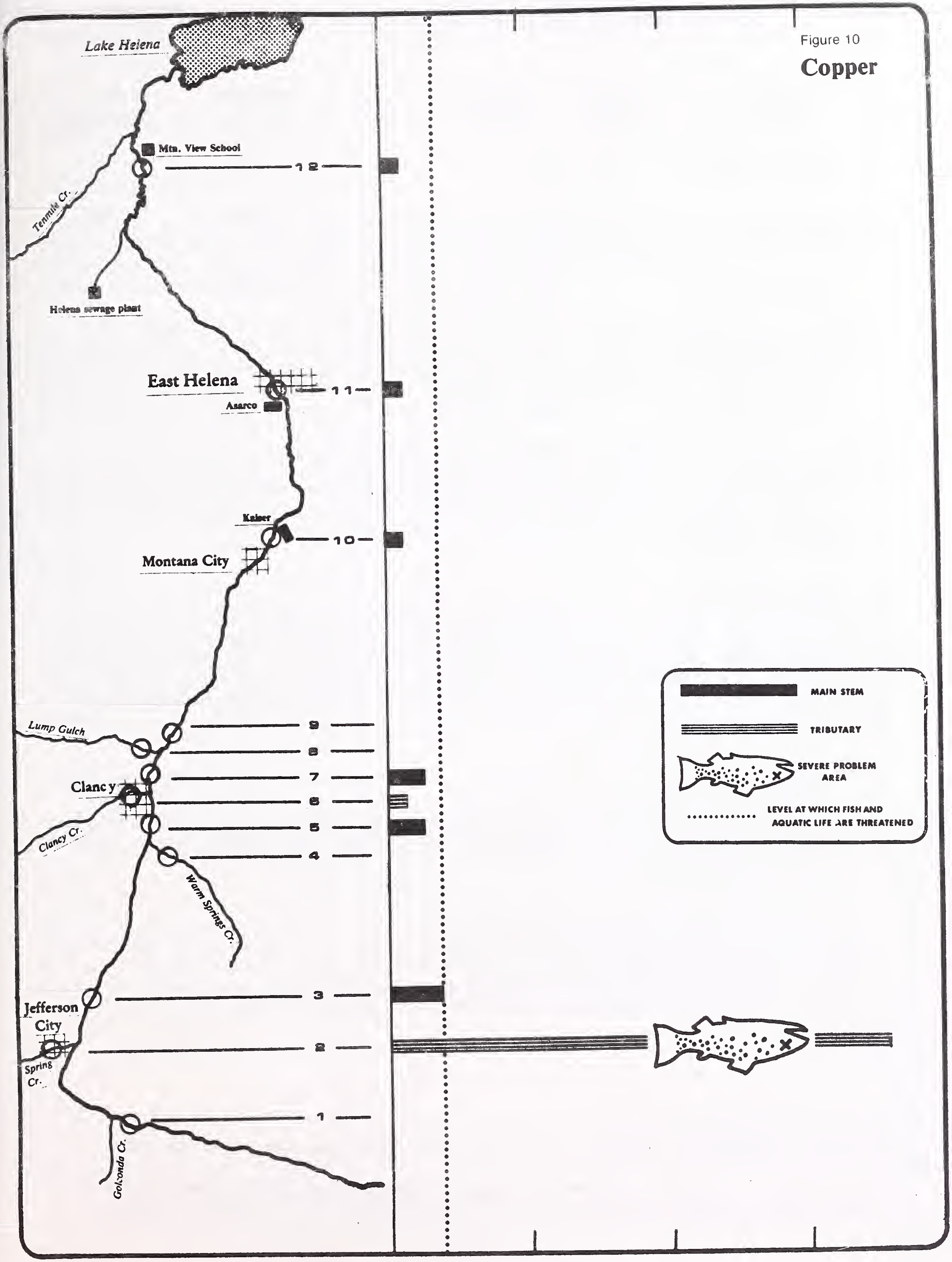


TABLE 12 Total Recoverable Copper (ug/l) in Prickly Pear Creek, 1979-1980

No.	Station Location	Sample size	Minimum value[1]	Mean	Maximum value	Number of exceedences[2]
1	Prickly Pear Cr. above Spring Cr.	6	0	0	10	0
2	Spring Cr. near mouth	6	0	290	1,000	5
3	Prickly Pear Cr. below Spring Cr.	6	0	30	110	3
4	Warm Springs Cr. near mouth	5	0	0	10	0
5	Prickly Pear Cr. below Warm Spg. Cr.	5	0	20	50	2
6	Clancy Cr. near mouth	5	0	10	30	1
7	Prickly Pear Cr. below Clancy Cr.	5	0	20	50	2
8	Lump Gulch Cr. near mouth	5	0	0	10	0
9	Prickly Pear Cr. below Lump Gulch Cr.	5	0	0	10	0
10	Prickly Pear Cr. at Montana City	5	0	10	20	1
11	Prickly Pear Cr. at East Helena	7	0	10	50	2
12	Prickly Pear Cr. at Mtn. View School	7	0	10	40	2

---

[1] Reported laboratory values of <0.01 mg/l (<10 ug/l) are assumed to be zero.

[2] The criterion to protect freshwater aquatic life varies with hardness and may be calculated using the formula $e^{(0.94\ [\ln\ (\text{hardness})]\ -\ 1.23)}$ (USEPA, 1980b).

Zinc

Rationale

Zinc is a heavy metal that is never found free in nature, but occurs as a sulfide, oxide or carbonate. Most of the zinc in aquatic environments is attached to bedload and suspended sediment particles. Zinc readily dissolves in strong acids and is therefore prominent in acid-mine discharges.

Like copper, zinc is far more toxic to aquatic life than to people and warm-blooded animals. Similarly, zinc toxicity varies with water hardness; the lower the hardness, the greater is the toxicity of zinc. As a rule of thumb, zinc should not exceed 47 ug/l as a 24-hour average concentration in order to assure protection of freshwater aquatic life (USEPA, 1980d).

As a constituent of drinking water, zinc imparts an undesirable taste and odor at higher concentrations. A water supply criterion has been set at 5 mg/l (5,000 ug/l) (USPHS, 1962). Recommended maximum concentrations of zinc for livestock watering and irrigation are 25 mg/l and 2.0 mg/l, respectively (USEPA, 1973).

Results

Zinc results are presented in Figure 11 and Table 13. On May 12, 1975, Spring Creek delivered 112,000 ug/l of zinc to upper Prickly Pear Creek, approximating a "worst case scenario". On that date, zinc in Prickly Pear Creek jumped from 50 ug/l immediately above Spring Creek to 55,000 ug/l below Spring Creek. The somewhat elevated upstream value might have been due to runoff from mined areas up Golconda Gulch.

Interpretation

On the basis of mean values and exceedences, only one source contributes significantly to the zinc problem in Prickly Pear Creek:

- Spring Creek

Excessive zinc is a product of mine wastes and acid-mine drainage in the Spring Creek watershed (Part III). Other tributaries were relatively free of this pollutant. Excessive zinc values and exceedences recorded elsewhere along the mainstream of Prickly Pear Creek represent residual zinc derived from Spring Creek, much of it associated with bedload and suspended sediment particles.

Figure 11

Zinc

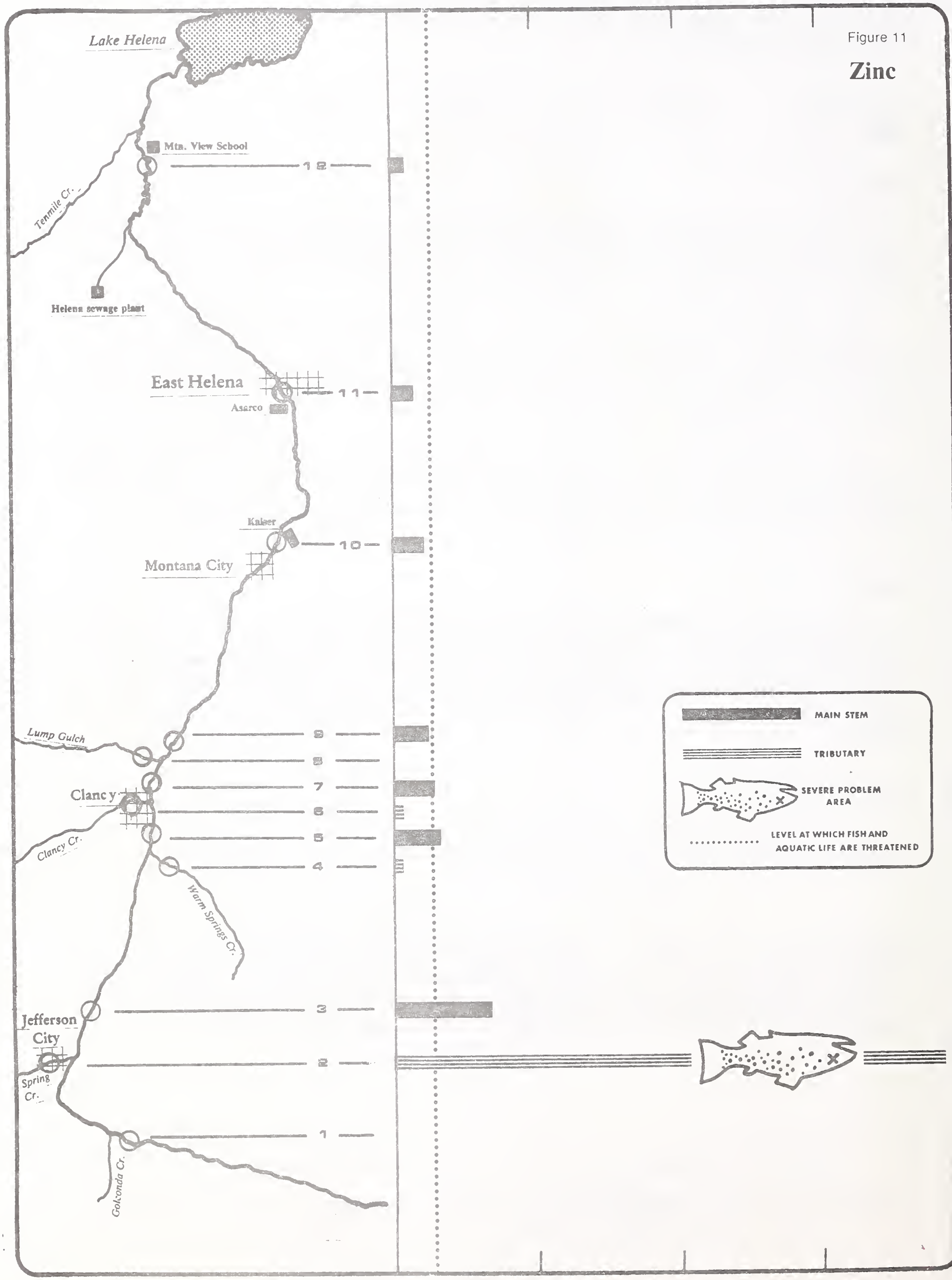


TABLE 13 Total Recoverable Zinc (ug/l) in Prickly Pear Creek, 1979-1980

No.	Station Location	Sample size	Minimum value[1]	Mean	Maximum value	Number of exceedences[2]
1	Prickly Pear Cr. above Spring Cr.	6	0	0	0	0
2	Spring Cr. near mouth	6	410	5,520	18,600	5
3	Prickly Pear Cr. below Spring Cr.	6	330	950	2,150	5
4	Warm Springs Cr. near mouth	5	20	80	230	1
5	Prickly Pear Cr. below Warm Spg. Cr.	5	220	440	1,030	3
6	Clancy Cr. near mouth	5	20	90	210	0
7	Prickly Pear Cr. below Clancy Cr.	5	180	380	880	2
8	Lump Gulch Cr. near mouth	5	0	10	20	0
9	Prickly Pear Cr. below Lump Gulch Cr.	5	180	330	610	2
10	Prickly Pear Cr. at Montana City	5	150	290	570	1
11	Prickly Pear Cr. at East Helena	6	100	180	390	1
12	Prickly Pear Cr. at Mtn. View School	6	30	120	340	1

---

[1] Reported laboratory values of <0.005 mg/l (<5 ug/l) are assumed to be zero.

[2] The criterion to protect freshwater aquatic life varies with hardness and may be calculated using the formula $e^{(0.83\,[\ln(\text{hardness})] + 1.95)}$ (USEPA, 1980d).

Diatoms

Rationale

Diatoms are microscopic one-celled plants that live on the bottom of Prickly Pear Creek and all other Montana streams. As plants, they are capable of using sunlight to energize the conversion of carbon dioxide and minerals into proteins, carbohydrates, and other compounds essential to growth.

The practical value of diatoms in streams is that they are the primary food source of certain small "bugs" or aquatic macroinvertebrates, which in turn are eaten by fish. Some stonefly larvae will graze on diatoms much the same way that cows will graze range grass. Diatoms also help streams recover from pollution by liberating oxygen and assimilating certain noxious substances like ammonia.

Healthy diatom communities generally have a large number of different kinds with no one kind dominating. Such a healthy community is said to have a high diversity. When subject to pollution, diatom communities lose diversity in proportion to the degree of pollution as the more sensitive kinds drop out. In extreme cases, a diatom community will be dominated by just a few kinds and diversity will be very low.

A measure of diversity commonly used to describe aquatic communities is the diversity index. One of the most popular and useful of these indexes is the Shannon-Weaver Index or $\bar{d}$ (Weber, 1973). For diatoms, community health and thereby water quality are generally reflected by the following ranges of $\bar{d}$ values (Bahls *et al*., 1979):

Diversity	Water Quality
>4.50	Excellent
3.50 - 4.50	Good
2.50 - 3.50	Fair
<2.50	Poor

Results

Diatom diversity results are presented in Figure 12 and Table 14.

Interpretation

Although only five mainstem Prickly Pear Creek stations were examined for diatoms, it is clear that the one source of pollution having the most devastating effect on the aquatic flora is:

- Spring Creek

Diatom diversity and water quality were best above Spring Creek and worst below Spring Creek. At Montana City the diatom community had recovered substantially but below East Helena it was once again put under considerable stress, reflecting

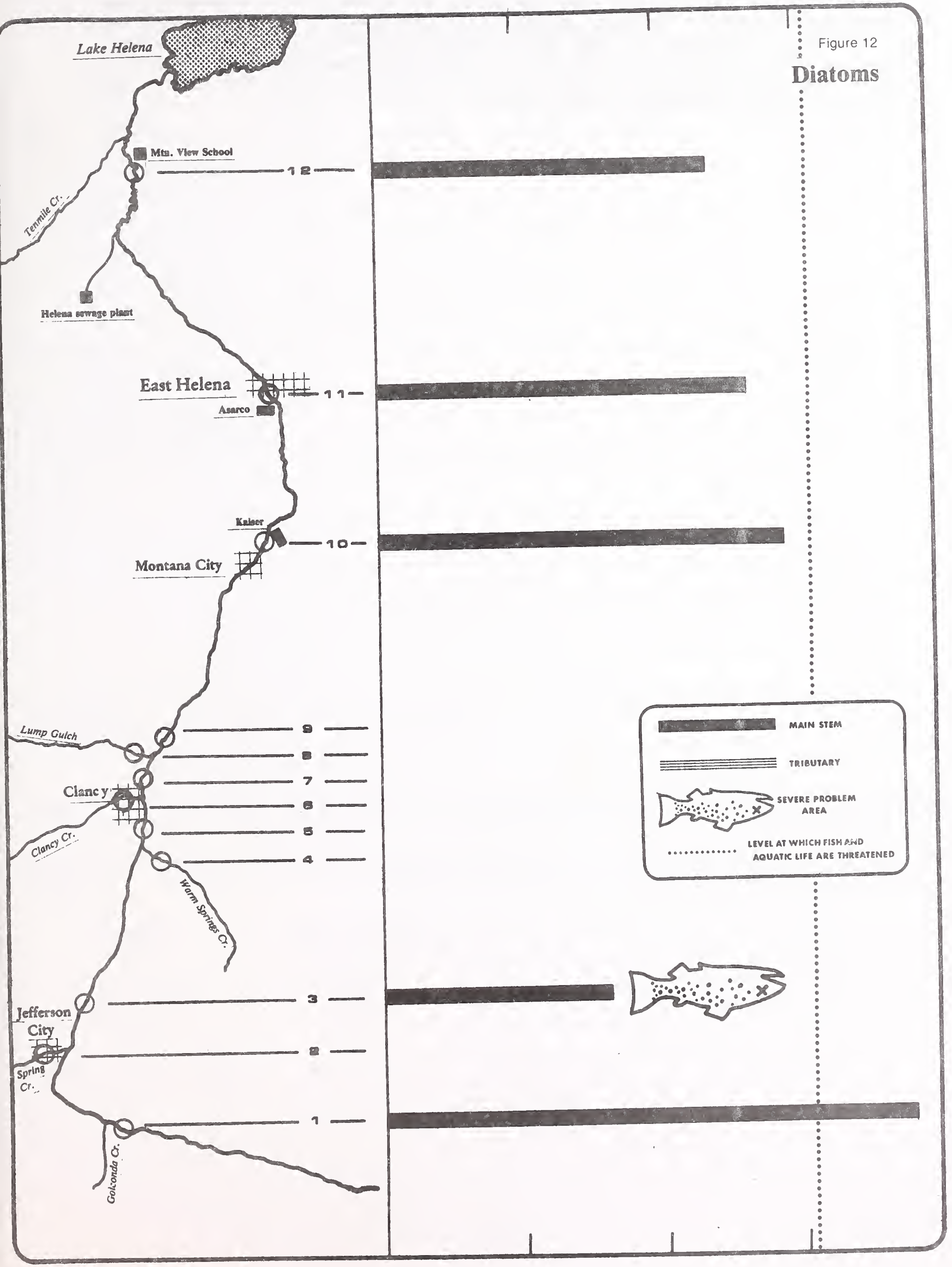


Figure 12

Diatoms

pollution from the Asarco East Helena facility, the Helena sewage treatment plant, and perhaps many smaller sources. Problems originating with the Asarco plant have been corrected or mitigated but the Helena sewage treatment plant discharge and perhaps the East Helena lagoon discharge, coupled with dewatering and a shifting, unstable substrate, continue to make this lower reach of Prickly Pear Creek a poor habitat for diatoms and other living things.

TABLE 14 Diversity[1] of Diatoms in Prickly Pear Creek, 1979

No.	Station Location	Sample size	Minimum value	Mean	Maximum value	Water Quality[2]
1	Prickly Pear Cr. above Spring Cr.	3	4.07	4.30	4.68	Good to Excellent
3	Prickly Pear Cr. below Spring Cr.	4	0.55	1.84	2.36	Poor
10	Prickly Pear Cr. at Montana City	4	2.75	3.27	3.59	Fair to Good
11	Prickly Pear Cr. at East Helena	3	1.52	2.99	3.73	Poor to Good
12	Prickly Pear Cr. at Mtn. View School	4	1.28	2.69	3.57	Poor to Good

---

[1] The formula for diatom species diversity is:

$$\bar{d} = \frac{C}{N} (N \log_{10} N - \Sigma n_i \log_{10} n_i)$$

where C = 3.321928; N = total number of individuals; and n_i = total number of individuals in the $_i$th species (Weber, 1973).

[2] Generally, water quality may be related to diatom diversity values in the following manner:

Diversity	Water Quality
>4.50	Excellent
3.50 - 4.50	Good
2.50 - 3.50	Fair
<2.50	Poor

(Bahls *et al.*, 1979).

Macroinvertebrates

Rationale

Macroinvertebrates are little animals without backbones that live in water. Most are the immature stages of insects that spend their adult lives out of the water. The practical value of macroinvertebrates is the linkage they provide between consumers (fish) and producers (diatoms) in aquatic ecosystems. Fish eat macroinvertebrates and macroinvertebrates eat diatoms, but fish don't eat diatoms. Thus without this central link in the food chain, fish would starve even if diatoms grew luxuriantly.

Healthy macroinvertebrate communities generally have a large number of different kinds with no one kind dominating. Such a healthy community is said to have a high diversity. When subject to pollution, macroinvertebrate communities will lose diversity in proportion to the degree of pollution as more sensitive forms drop out. In extreme cases, a macroinvertebrate community will be dominated by just a few different kinds and diversity will be very low.

A measure of diversity commonly used to describe aquatic communities is the diversity index. One of the most popular and useful of these indexes is the Shannon-Weaver Index or $\bar{d}$ (Weber, 1973). For macroinvertebrates, community health and thereby water quality are generally reflected by the following ranges of $\bar{d}$ values (Bahls *et al*., 1979):

Diversity	Water Quality
>3.50	Excellent
2.50 - 3.50	Good
1.50 - 2.50	Fair
<1.50	Poor

Results

Macroinvertebrate diversity results are presented in Figure 13 and Table 15.

Interpretation

As with the diatoms, the single source of pollution having the most profound effect on the macroinvertebrate community is:

- Spring Creek

Mean macroinvertebrate diversity drops by a third from above to below Spring Creek due to a combination of heavy metals and sediment pollution. The residuals from Spring Creek together with perturbations along the mainstem of Prickly Pear Creek

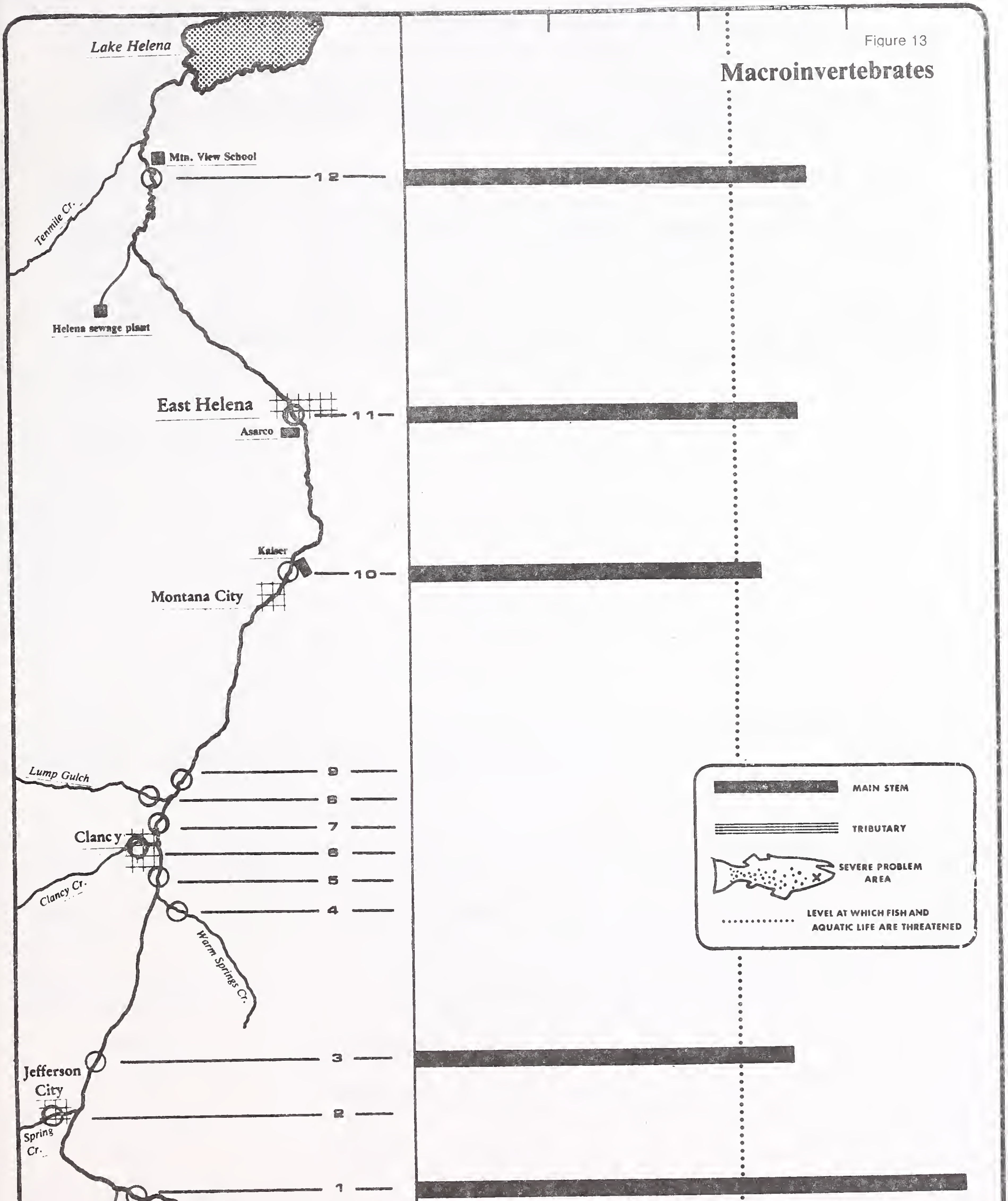


Figure 13

Macroinvertebrates

foster an even less healthy diversity at Montana City. From here downstream the macroinvertebrate community recovers but little and never regains its full potential. Both the macroinvertebrate and diatom results suggest that the multiple pollution sources from Spring Creek downstream preclude either community from attaining total recovery and some semblance of the biological health enjoyed by Prickly Pear Creek in its headwaters.

Macroinvertebrate diversity is clearly less affected by Spring Creek pollution than is diatom diversity. Diatoms and other algae may be more sensitive to heavy metals, particularly copper, which is the active ingredient in certain commercial algaecides. Populations of macroinvertebrate species tend to be more uniformly reduced in the face of metals pollution than populations of diatoms, which tend to be more differentially sensitive to or tolerant of heavy metals. Finally, macroinvertebrates can repopulate poisoned reaches quickly by natural downstream drift from unaffected reaches. Diatoms, many of which are permanently attached to the substrate, are not nearly as mobile.

TABLE 15 Diversity[1] of Macroinvertebrates in Prickly Pear Creek, 1979-1980

No.	Station Location	Sample size[2]	Minimum value	Mean	Maximum value	Water Quality[3]
1	Prickly Pear Cr. above Spring Cr.	5	3.78	4.22	4.51	Excellent
3	Prickly Pear Cr. below Spring Cr.	12	2.49	2.90	3.53	Fair to Excellent
10	Prickly Pear Cr. at Montana City	11	1.93	2.71	3.46	Fair to Good
11	Prickly Pear Cr. at East Helena	19	2.23	3.01	3.50	Fair to Good
12	Prickly Pear Cr. at Mtn. View School	20	2.36	3.07	3.79	Fair to Good

---

[1] The formula for macroinvertebrate genus diversity is:

$$\bar{d} = \frac{C}{N} (N \log_{10} N - \sum n_i \log_{10} n_i)$$

where C = 3.321928; N = total number of individuals; and n_i = total number of individuals in the $_i$th genus (Weber, 1973).

[2] Sample size may include up to nine replicate samples taken on a given date at a given station.

[3] Generally, water quality may be related to macroinvertebrate diversity values in the following manner:

Diversity	Water Quality
>3.50	Excellent
2.50 - 3.50	Good
1.50 - 2.50	Fair
<1.50	Poor

(Bahls *et al.*, 1979).

Summary, conclusions and recommendations

Summary and conclusions

A summary of criteria exceedences at all stations along Prickly Pear Creek is presented in Table 16. Based on the eleven chemical/physical parameters covered in this report, Table 16 indicates the relative suitability or fitness of water at each station for the uses indicated.

Each number in Table 16 represents the number of times a criterion for a given parameter was exceeded by a measured value for that parameter, expressed as a percentage of all possible criterion/value comparisons. For example, the measured parameter value exceeded the criterion for that parameter in twelve of the sixteen possible criterion/value pairs among the three public health related parameters at Station 2, giving an exceedence percentage of 75 percent. The overall or "All Uses" exceedence percentage considered all possible criterion/value pairs, even though a single parameter value may have been paired with up to four criteria for that parameter at a given station.

The following conclusions may be drawn from this summary analysis:

1. The most severe water pollution problem in the Prickly Pear Creek drainage is Spring Creek.
2. Spring Creek has a significant impact on the water quality of Prickly Pear Creek below their confluence.
3. Among mainstem stations on Prickly Pear Creek, water quality is best above Spring Creek and worst at Mountain View School below the Helena sewage treatment plant discharge.
4. Below Spring Creek, water quality in Prickly Pear Creek is best at Montana City but it never fully recovers to its headwaters condition.
5. The poor water quality situation in Prickly Pear Creek caused by pollutants discharged from Spring Creek is not appreciably worsened by pollutants picked up from the other major tributaries or along the mainstem.
6. In descending order of severity, the water uses impaired or potentially impaired by pollution in the Prickly Pear Creek drainage are: aesthetics, public health, aquatic life, irrigation, and stock watering.

TABLE 16 Percent Criteria Exceedences for Different Water Uses, Prickly Pear Creek, 1979-1980

Station No.	All Uses	Public Health	Aesthetics	Irrigation	Stock Water	Aquatic Life
1	1	0	3	0	0	0
2	46	75	59	47	18	44
3	17	0	29	18	0	23
4	8	7	23	0	0	9
5	16	7	33	13	0	17
6	12	13	27	3	0	11
7	15	7	33	10	0	14
8	11	7	37	3	0	3
9	16	7	40	13	0	11
10	13	7	33	10	0	8
11	16	20	33	12	0	9
12	31	50	71	7	4	19
Parameters and Criteria						
Turbidity		5 TU				
Arsenic		50 ug/l		100 ug/l	200 ug/l	440 ug/l
Lead		50 ug/l		5,000 ug/l	100 ug/l	*
Iron			0.3 mg/l	5.0 mg/l		1.0 mg/l
Manganese			0.05 mg/l	0.2 mg/l		
Nitrogen			0.35 mg/l			
Phosphorus			0.05 mg/l			
Sediment						80 mg/l
Ammonia						0.016 mg/l
Copper			1.0 mg/l	0.2 mg/l	0.5 mg/l	*
Zinc			5.0 mg/l	2.0 mg/l	5 mg/l	*

*Criterion depends on hardness

Recommendations

The following general order of priorities for pollution abatement in the Prickly Pear Creek drainage appears to be consistent with the findings of this overview study:

1. Stabilize or remove significant sources of sediment and heavy metals in the Spring Creek drainage.
2. Improve wastewater treatment at the Helena sewage treatment plant in order to reduce the concentrations of un-ionized ammonia and other pollutants discharged to lower Prickly Pear Creek.
3. Stabilize significant sediment sources along Warm Springs Creek, Clancy Creek and Lump Gulch Creek.
4. Stabilize significant sediment sources along the mainstem of Prickly Pear Creek above East Helena.
5. Stabilize significant sediment sources along the mainstem of Prickly Pear Creek below East Helena.
6. Ensure that efforts to control untimely sediment flushing and fugitive discharges from the Asarco East Helena facility are carefully maintained.
7. Investigate, and control as necessary, other possible sources of pollution to Prickly Pear Creek, including urban stormwater runoff from Helena and East Helena, the East Helena lagoon discharge, irrigation return flows, animal confinement facilities, and on-site sewage disposal systems.

Although not specifically addressed by this water quality overview, the seasonal dewatering of lower Prickly Pear Creek clearly aggravates an already critical water quality situation and precludes the establishment of a viable fishery. The rewatering of lower Prickly Pear Creek should be an integral part of any pollution abatement program for this stream and efforts to achieve this goal should keep pace with the pollution control efforts recommended above.

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Appendix A

Appendix A. Existing water-use classifications for Prickly Pear Creek and its tributaries (Administrative Rules of Montana, 9/30/80, 16-885)

McClellan Creek drainage to the East Helena water supply intake and Ten Mile Creek drainage to the Helena water supply intake . . . . . . A-1. Waters classified A-1 are suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities.

Mainstem Prickly Pear Creek above the Montana Highway No. 433 crossing about one mile northwest of East Helena and all tributaries of Prickly Pear Creek except those portions named above . . . . . . B-1. Waters classified B-1 are suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

Mainstem Prickly Pear Creek from the Montana Highway No. 433 crossing about one mile northwest of East Helena to Lake Helena . . . . . . E. Waters classified E are suitable for agricultural and industrial water uses other than food processing.

Part II

Prickly Pear Creek Streambank Physical Features Inventory

Water Quality Bureau
Department of Health & Environmental Sciences

June 1981

Contact person: Ken Chrest, 449-2406

What we found

The Prickly Pear Streambank Physical Features Inventory was conducted during the first two weeks of August, 1980. The inventory surveyed 164,310 feet of stream (more than 31 miles) and found:

- 127,122 feet of streambank alterations (this total includes both the right and left banks)
- 37,163 feet of blanket riprap
- 5 rock jetties
- 58 car bodies
- 6,693 feet of river gravel moved by machinery
- 2,276 feet of other alterations (fencelines, dredge tailings, etc.)
- 22 irrigation take-offs
- 9 irrigation return flows
- 1 illegal sewage discharge from a house
- 22,712 feet of eroding banks
- 6,745 feet of "mass-wasting" (erosion on a larger, faster scale)
- 319 feet of vertical non-eroding banks (potential mass-wasting sites)
- 365 feet of debris jams
- 48 channel obstructions or fish barriers

The inventory is broken down section-by-section -- moving upstream from Lake Helena to near the headwaters and including major tributaries -- in the following pages.

How we found it

Fifteen persons did the field work for the Prickly Pear streambank inventory. They were from the Soil Conservation Service, Bureau of Land Management, Water Quality Bureau, Department of Fish, Wildlife and Parks, and the Lewis and Clark County Conservation District. They split into five teams, with two or three persons in each team for the two weeks. Each team was assigned a particular section.

The teams used stream-inventory field forms and aerial photographs (scale of 1"=250', taken by the Highway Department in May 1980), and covered almost the entire length of the creek and several major tributaries. The exceptions were the extreme upper end of the Prickly Pear mainstem (above Golconda Creek) and Lump Gulch (see the section on Lump Gulch for an explanation).

Streambank sections disturbed by man were measured directly from the aerial photographs and recorded on the field forms. Features identified during the inventory also were inked onto the photographs for permanent reference.*

Features so identified during the inventory were:

- Stream-channel alterations
- Streambank alterations
    - blanket rock riprap
    - rock jetties
    - car bodies
    - river gravel
    - other alterations (dredge tailings, brush piles, etc.)
- Irrigation take-offs and return flows
- Eroding banks
- Bank "mass-wasting"
- Vertical non-eroding banks (potential mass-wasting sites)
- Debris jams
- Streambed material (the composition of the creek bottom)
- Channel obstructions
- Mine wastes
- Mine drainage
- Settling ponds

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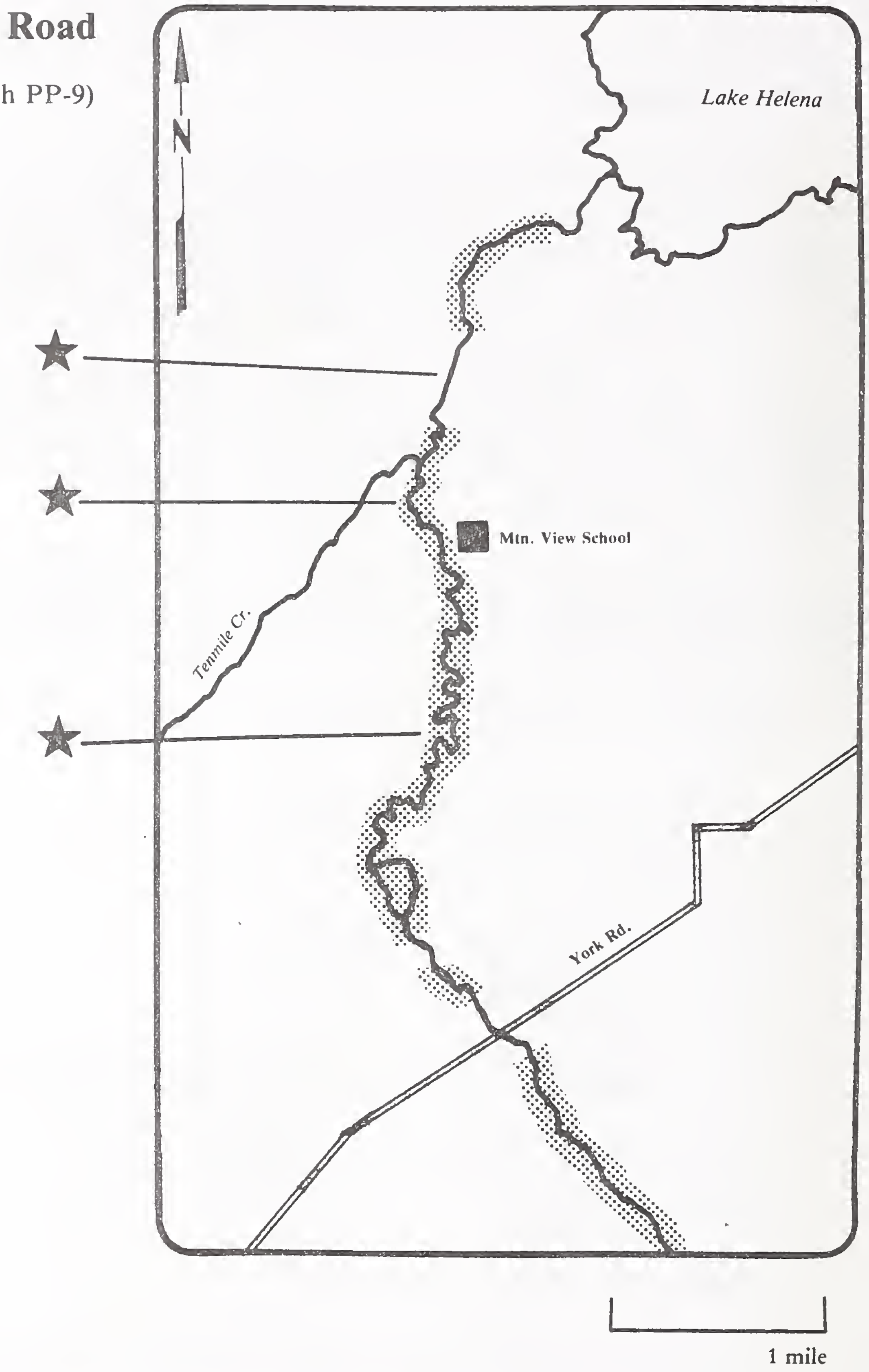
*The aerial photographs have been deposited in the office of the Lewis and Clark County Conservation District, Federal Building, Helena.

Figure 14

Lake Helena to York Road

(see aerial photos PP-1 through PP-9)



▨ Eroding banks

★ Major areas of mass wasting

Lake Helena to York Road

As shown on the map on the facing page, the most prominent problems identified in this section of Prickly Pear Creek are associated with streambank erosion and mass wasting. Mass wasting is a term that describes a relatively large chunk of streambank that has suddenly fallen into the stream. Although erosion and mass wasting are natural phenomena -- part of a stream's meandering process -- they can be accelerated, which isn't good, by the removal of vegetation.

Current land uses and related activities in this stretch of the Prickly Pear make it clear that the problems are accelerated primarily by agriculture. Cattle activity is the main source of degradation. Moderate to heavy grazing in these riparian zones has depleted streambank vegetation and aggravated naturally unstable soil conditions. This removal of the natural protective cover has accelerated the erosion, and periods of heavy use of these fragile areas has induced streambank sloughing which has increased the amount of sediment in the stream.

Much of the stream channel in this section is filled with sediment which alters the physical shape of the creek and smothers aquatic insect life. Ranching practices can't be given the total blame for this, however, since much of the sediment has travelled from far upstream -- mainly from mining areas -- before settling out in the lower Prickly Pear.

Possible corrective measures

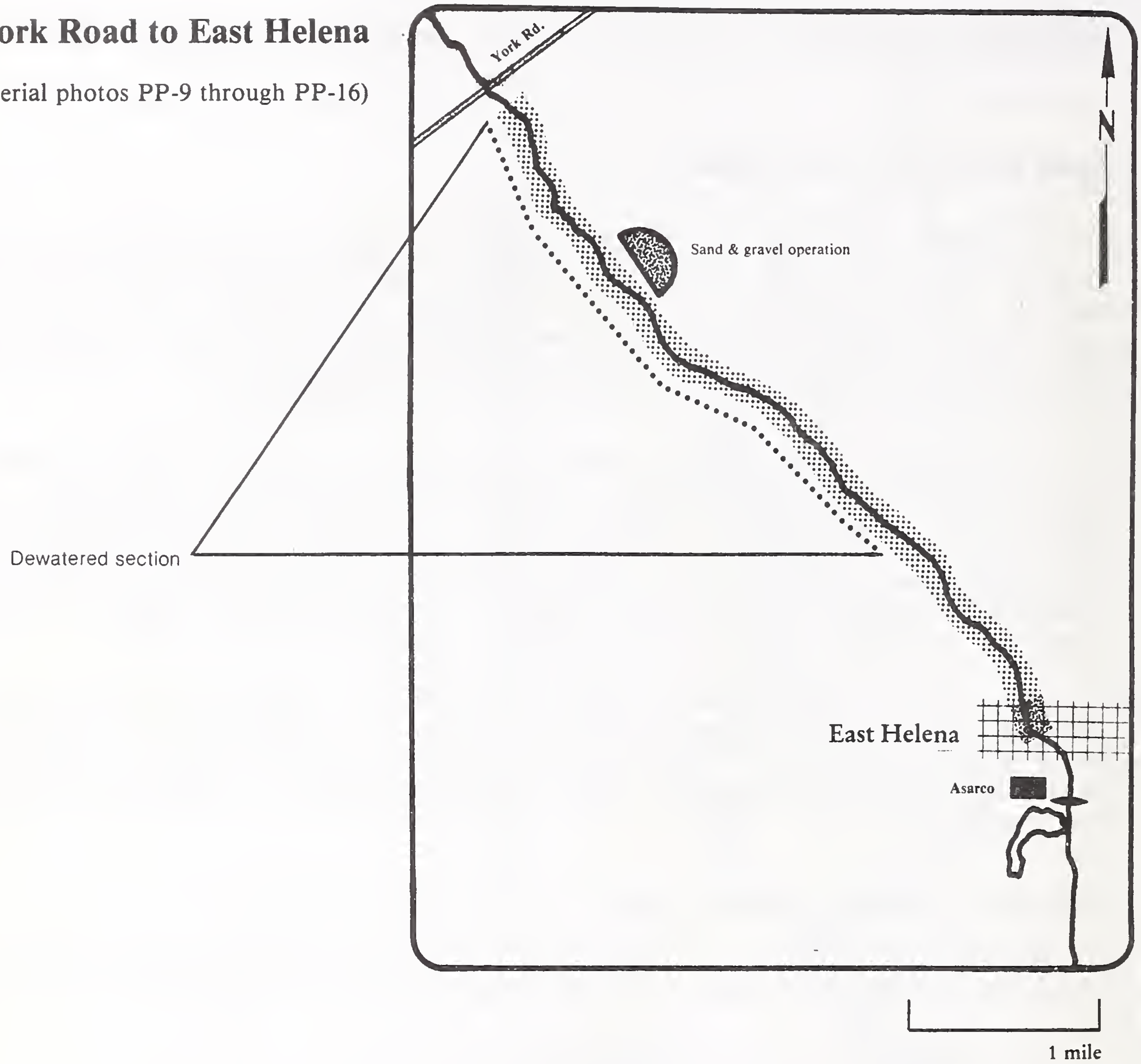
Methods for impeding pollution from the sediments contributed to Prickly Pear Creek by ranching along this section are:

- Adjusting cattle stocking rates
- Seasonal or rest-rotation grazing
- Dispersal of livestock away from the creek
- Relocation of salting areas for livestock
- Fencing off the stream in critical areas
- Discouraging of cattle traffic at fragile streambank crossings
- Revegetation with native plants
- Riprapping in conjunction with revegetation

Figure 15

York Road to East Helena

(see aerial photos PP-9 through PP-16)



▨ Eroding banks

▩ Altered stretch & blanket riprap

▬ Major fish barrier (Asarco dam)

York Road to East Helena

This stretch of the Prickly Pear has problems similar to those identified for the previous section. Again, the major causes of the disturbed areas are linked to agriculture -- but a large sand-and-gravel operation also has helped denude the streambanks and contribute to erosion and sediment.

To contain the stream in its channel, Man has altered the channel significantly and riprapped the streambanks.

Two other conditions existing in this stretch are (1) a definite decrease in streambank vegetation, even over the previous section, and (2) a dewatering condition due to irrigation withdrawals. During certain periods of the late-summer irrigation season, a substantial stretch of the Prickly Pear below East Helena is without any flowing water at all.

Possible corrective measures

The corrective measures for livestock grazing listed on the previous page can be applied to this stretch. Such solutions for restoring the riparian zone will require a great amount of cooperation from the land occupants. An intense revegetation program through this reach not only will help stabilize the streambank and control erosion and keep sediment from reaching the creek, but also will keep water temperatures cool and improve the overall aesthetics of the rather barren-looking area.

Before plants can flourish once again upon the streambanks, landowners will have to cooperate fully in restraining livestock grazing. The owners of the gravel-mining operation, too, will have to cooperate in a program to restore the streambanks. The obvious organizer of such a cooperative program among landowners in this reach would be the Lewis and Clark County Conservation District.

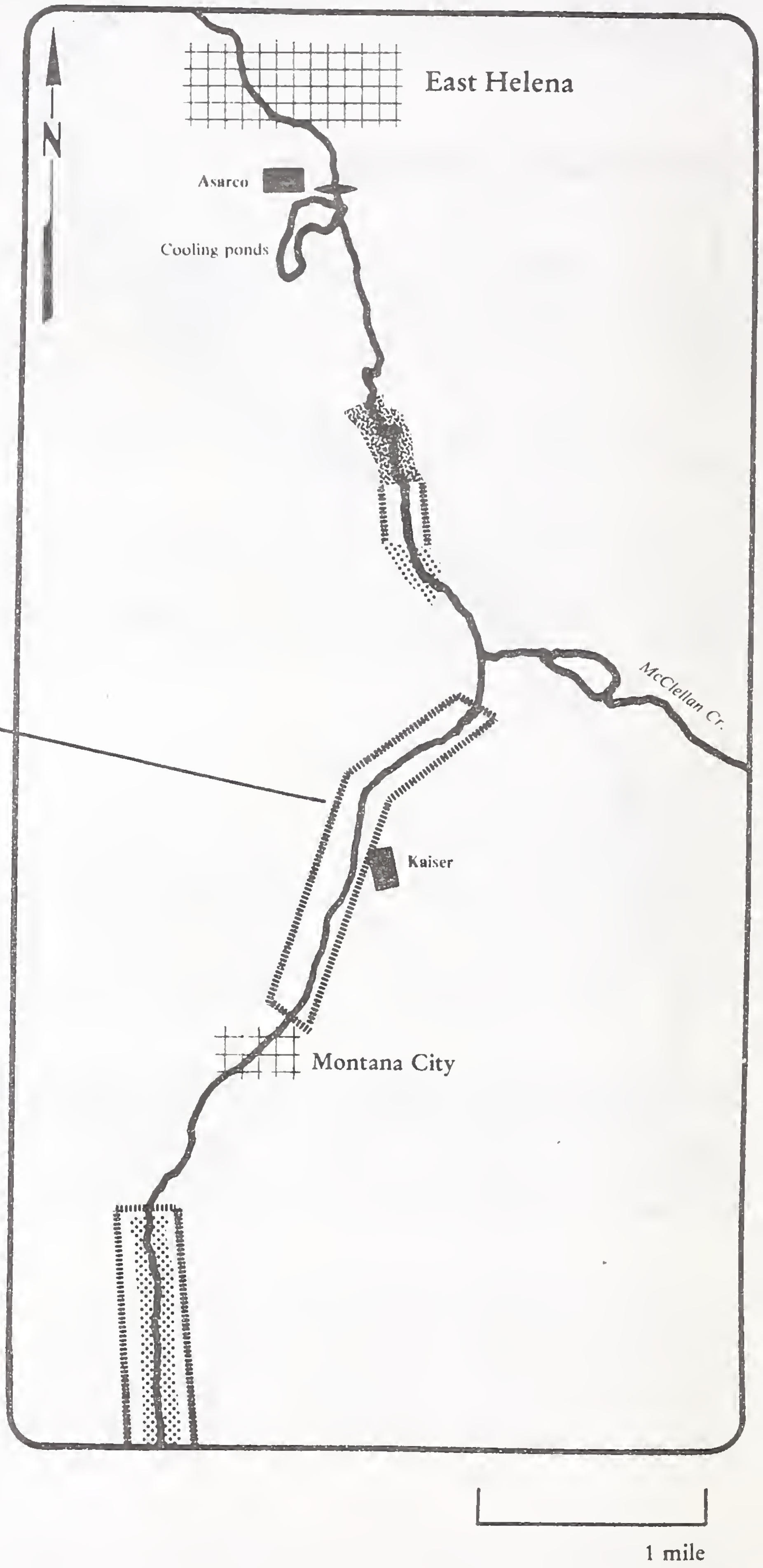
As this report is being written, one major landowner along the dewatered section of the creek is volunteering to swap his water right to the Prickly Pear if another irrigation source can be found. For this trade to take place, clarifying legislation must be passed by the Montana Legislature. Such a bill was drawn up for the 1981 Legislature, but was not introduced because more study of its legalities was needed. Another attempt will likely be made during the 1983 Legislature.

If the water right is allowed to revert to an instream flow, this stretch of the creek would no longer go dry during a normal year. This would also allow the upgrading of this stretch's poor water-quality classification, which is based primarily on its dewatered status (see Parts V and VI of this report).

Figure 16

East Helena to Montana City

(aerial photos PP-14 through PP-24)



This altered section "healed" by natural revegetation

░ Eroding banks

▭ Altered stretch

▓ Major riprap area

⬬ Major fish barrier (Asarco dam)

East Helena to Montana City

If you ignore the blanket riprap through East Helena and on the west side of the creek at Asarco, this section of the Prickly Pear is fairly stable -- its streambanks are in relatively good condition. Man's major influences on this section are alterations and the riprap. There are some problems with a lack of vegetation and, consequently, eroding banks.

In the lower section of this stretch, at Asarco, the smelter's slag piles, which form the west bank of the creek, are void of vegetation. Just above the slag piles is Asarco's dam, which is a complete barrier to the upstream movement of fish. And behind the dam is a good-sized impoundment of water -- a major creek alteration which also traps sediment coming down from upstream.

The section halfway between East Helena and Montana City suffers some accelerated erosion, although corrective riprap measures have been implemented.

The upper reach, near Montana City, has been altered, but the vegetation has recovered in the riparian zone along this channel.

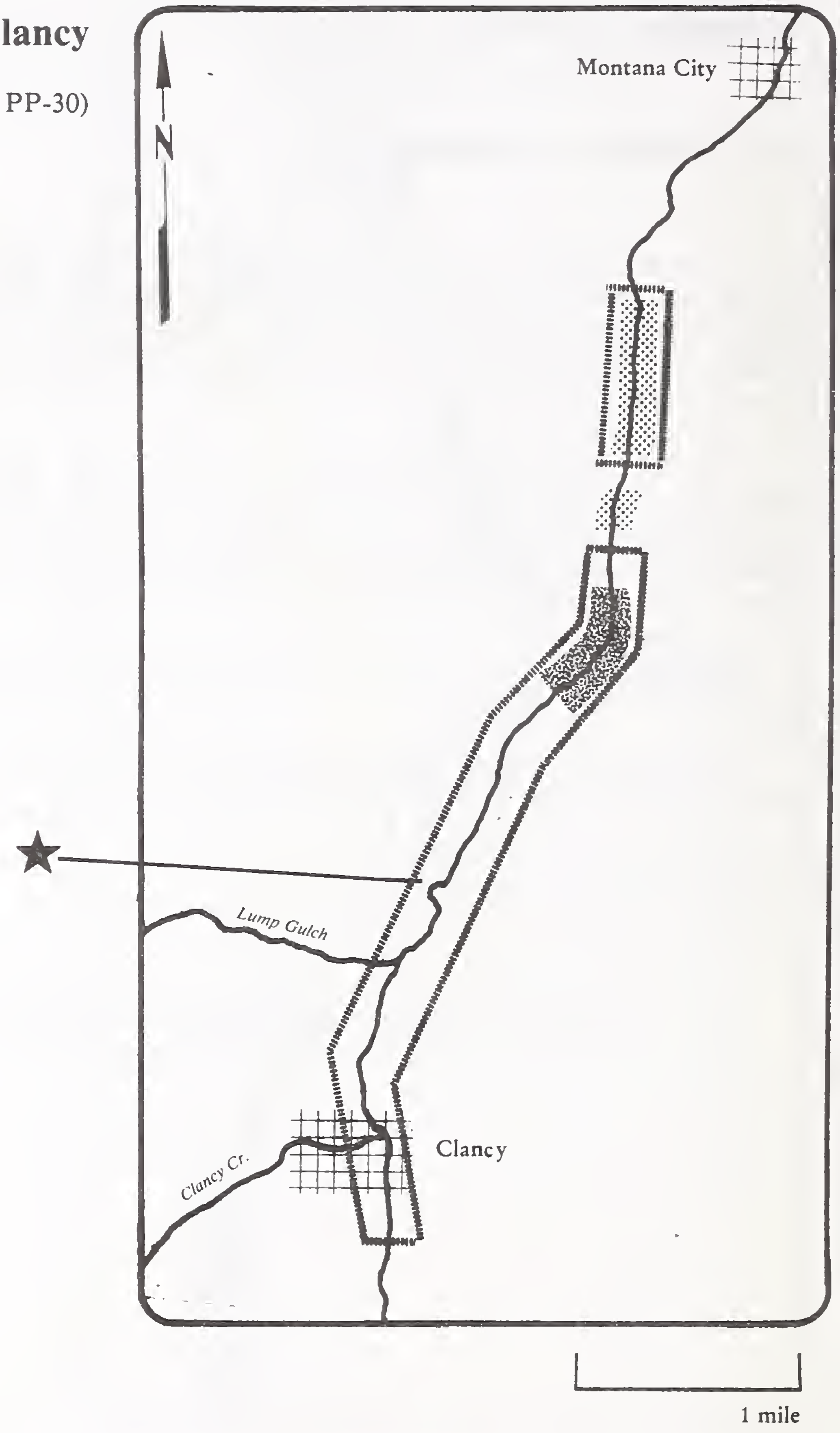
Possible corrective measures

- Revegetation where needed
- The agriculture-related remedies mentioned in the two previous sections

Figure 17

Montana City to Clancy

(aerial photos PP-21 through PP-30)



▒ Eroding banks

▓ Major riprap area

☐ Altered stretch

★ Mass wasting

Montana City to Clancy

As shown on the map, Man has had little adverse impact on the Prickly Pear in the vicinity of Montana City. Although this section of the stream has been altered, nature has taken its own corrective action -- "healing" this area by establishing voluntary vegetation.

Upstream from this site, however, is a portion of the creek that has been transformed significantly by Man. Channel alterations are the most obvious impacts, caused mainly by the encroachment of the interstate highway and the railroad. Through channelization, the stream's gradient has been steepened; this, in turn, has increased the water's velocity. As a result, the stream's erosive power also has increased.

Eroding banks, riprap and some mass wasting also were noted in this stretch during the inventory.

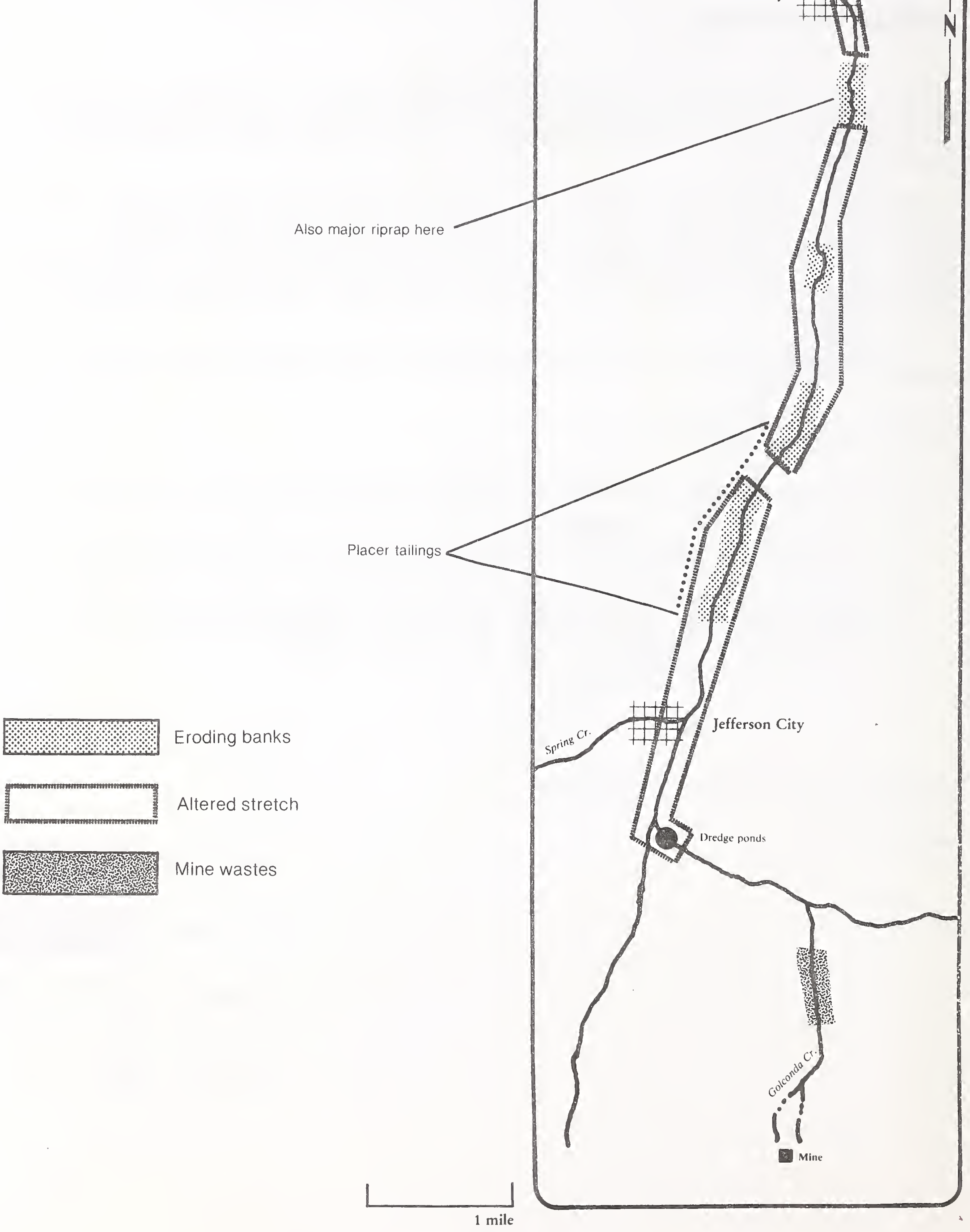
Possible corrective measures

- The planting of native plant species could improve the eroding bank areas.
- Mass wasting may be a natural phenomenon, but some of these areas could be improved by backsloping, riprapping and planting of native vegetation.
- In the channelized areas, installation of check dams and increasing the channel roughness are two methods that might be economically feasible for dissipating the stream's velocity and reducing erosion.

Figure 18

Clancy to Golconda Creek

(aerial photos PP-30 through PP-46)



Clancy to Golconda Creek

The portion of the creek above Clancy has most of the problems addressed in the previous sections of this inventory: erosion accelerated by a lack of vegetation, and channelization.

However, a new problem comes into play in this section: the presence of placer-mining tailings left along long stretches of the creek by a massive, floating dredge. Vegetation is having a difficult time establishing itself on much of these tailings, and they are left open to erosion.

Another potential mine-related problem area in this section is Golconda Creek. This tributary rubs shoulders with mine spoils in the Golconda mining area and could be a source of the minor metal and sediment pollution found in the upper stretches of the Prickly Pear.

Possible corrective measures

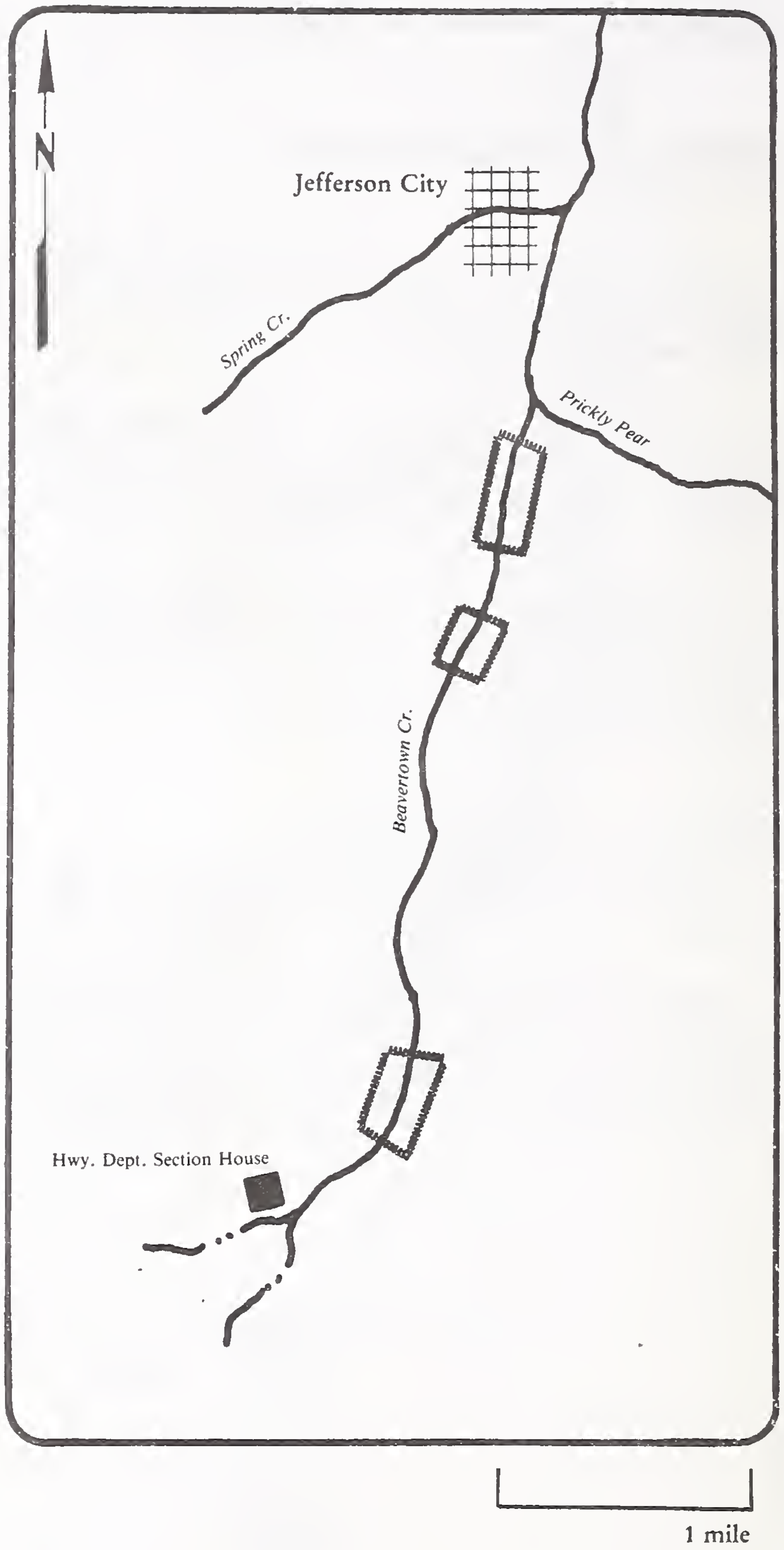
Suggested corrective actions already have been addressed in the foregoing pages of this inventory report, except for measures in reaction to the mining area.

And corrective measures for the Golconda Mine area are beyond the scope of this report because the inventory did not cover the entire Golconda area. For further explanation of mining impacts, see the sections on Corbin and Spring Creeks in the streambank inventory, and also Part III of the overall report.

Figure 19

Beavertown Creek

(aerial photos B-1 through B-10)



▭ Altered stretch

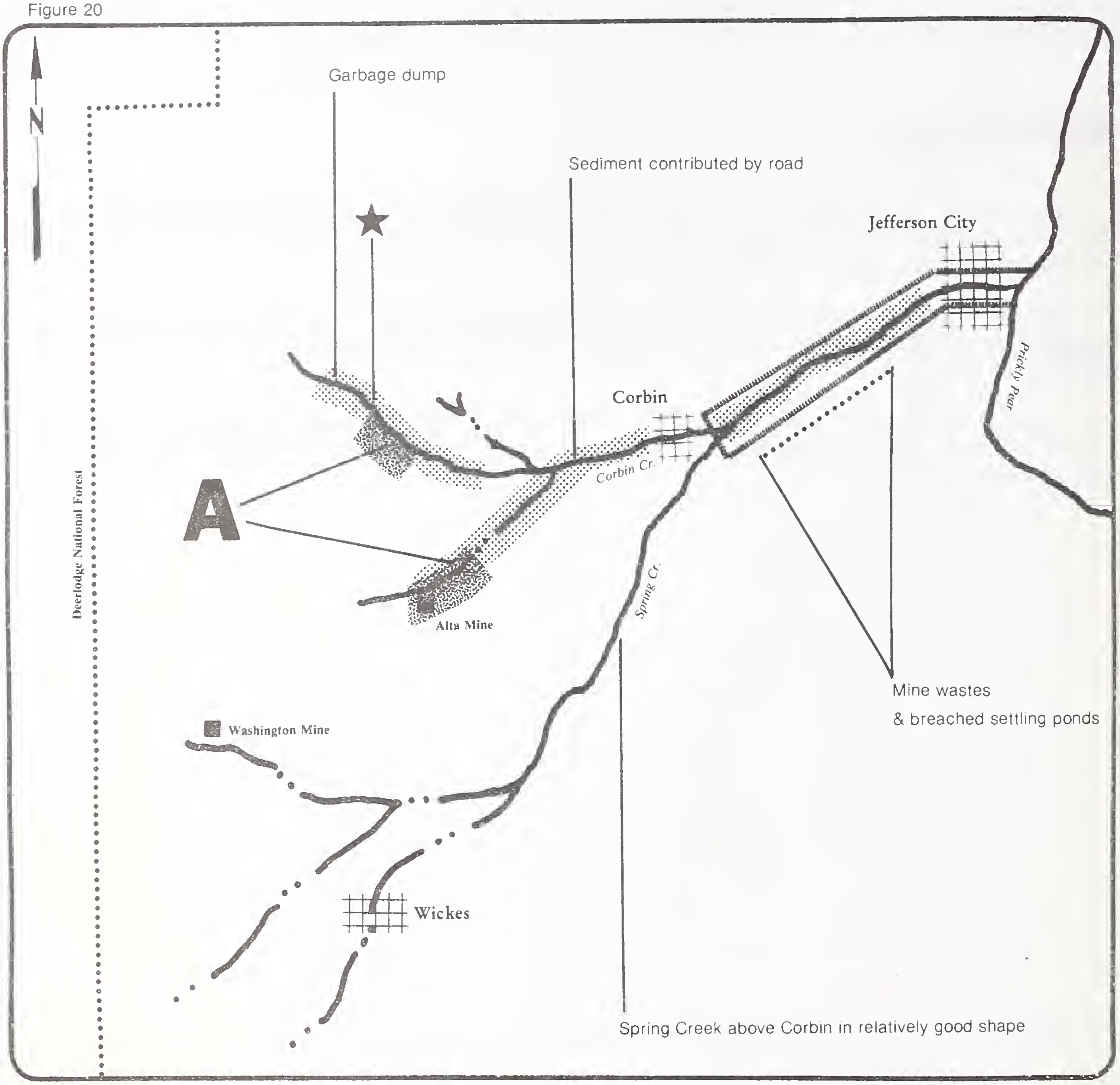
Beavertown Creek

This part of the inventory began near the headwaters of Beavertown Creek, not far from the summit of "Boulder Hill" and Interstate-15. It ends at the confluence of Beavertown and Prickly Pear Creeks.

The streambank problems on Beavertown Creek are minor -- the most significant is stream-channel alteration, much of it due to highway construction. There is some minor erosion.

Vegetation along this tributary is increasing and is in good condition. Therefore, correction of the minor erosive areas on Beavertown Creek should be give a low priority.

Figure 20


N
Garbage dump
Sediment contributed by road
Jefferson City
Corbin
Corbin Cr.
Prickly Pear
Deerlodge National Forest
A
Alta Mine
Spring Cr.
Mine wastes
& breached settling ponds
Washington Mine
Wickes
Spring Creek above Corbin in relatively good shape
1 mile

Corbin and Spring Creeks

(aerial photos SC-1 through SC-7 and C-1 through C-5)

★ Mass wasting

░ Eroding banks

▨ Mine wastes

☐ Altered stretch

A Acid mine-drainage

Corbin and Spring Creeks

The survey team started above the mine dumps on Corbin Creek, headed east to the confluence of Corbin and Spring Creeks, and further east to the confluence of Spring and Prickly Pear Creeks. The problems they found on Corbin and Spring Creeks are mind-boggling.

Man's activities in this area have devastated or altered the entire reaches of the streams that were surveyed. Mining has taken the biggest toll. Abandoned mine adits and seepage are pouring acid-laden water, via Corbin and Spring Creeks, into the Prickly Pear. Mine tailings are positioned as if they were designed specifically to contribute acids and sediment to the water. Settling ponds just below the confluence of Corbin and Spring Creeks have breached, and are now a major source of sediment.

Mass wasting and eroding banks -- also major sources of sediment -- are prevalent throughout the reach. Woody vegetation is practically nil -- why, we don't know. A spot near the Corbin Creek mining area has been used as a garbage dump.

In a mile-long stretch below the town of Corbin, Spring Creek's channel has been relocated completely. Above the town of Corbin, Spring Creek is in fairly good condition and was not surveyed.

Possible corrective measures

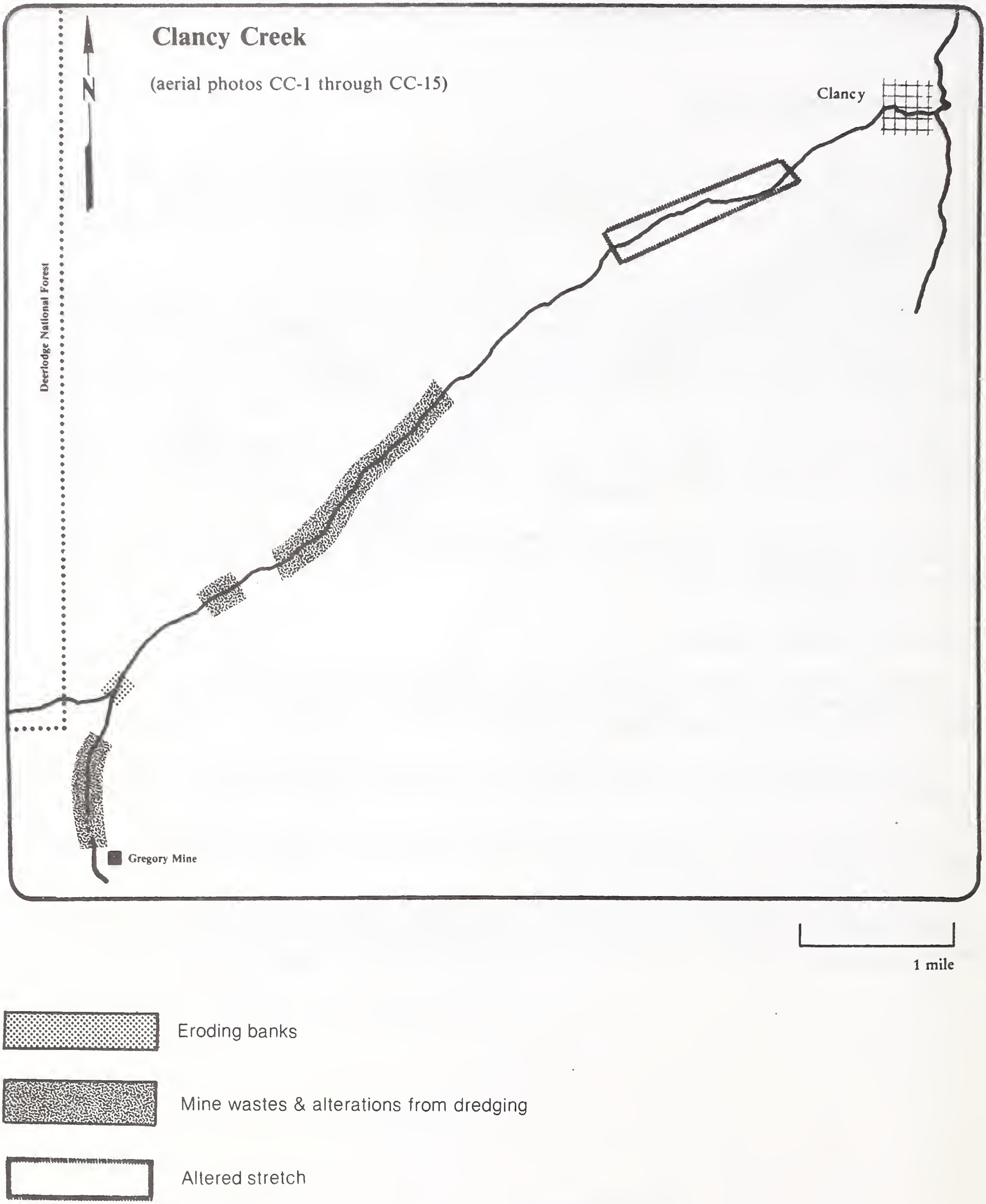
Rehabilitation of this area will take an enormous amount of effort, time and money. Reclamation plans may have to be developed for this area -- especially to stop the flow of acid water into the creeks.

Design and feasibility studies should be conducted to return Spring Creek to its original, meandering channel.

Soil samples must be taken and analyzed to determine if toxic chemicals in the soil are prohibiting revegetation.

Other, less costly, measures could be initiated along certain portions of the creeks, such as planting vegetation, removing junk, and controlling the erosion and sediment contribution from the dirt road along Corbin Creek.

Figure 21


Clancy Creek
(aerial photos CC-1 through CC-15)
N
Clancy
Deerlodge National Forest
Gregory Mine
1 mile
Eroding banks
Mine wastes & alterations from dredging
Altered stretch

Clancy Creek

The survey includes the stretch of Clancy Creek from the Gregory Mine to the creek's confluence with the Prickly Pear at Clancy.

Mining, again, is the dominant influence on the creek; but eroding banks, mass wasting and channel alterations also exist.

The upper reach of Clancy Creek is the home of two abandoned mine sites which could be contributing pollutants. Mine spoils sit next to the stream and are void of vegetation. At the time of the survey, a drill rig was taking core samples from a site adjacent to this old mining area -- portending, perhaps, the arrival of new mining.

Dredge mining also has left its mark on Clancy Creek. About halfway down the creek, dredging has altered the channel several times, and the present channel is completely out of the original banks. Because of this relocation, the stream at this point is still in its "infant" stage, trying to seek its own course. And as it does, bank erosion and sloughing will occur.

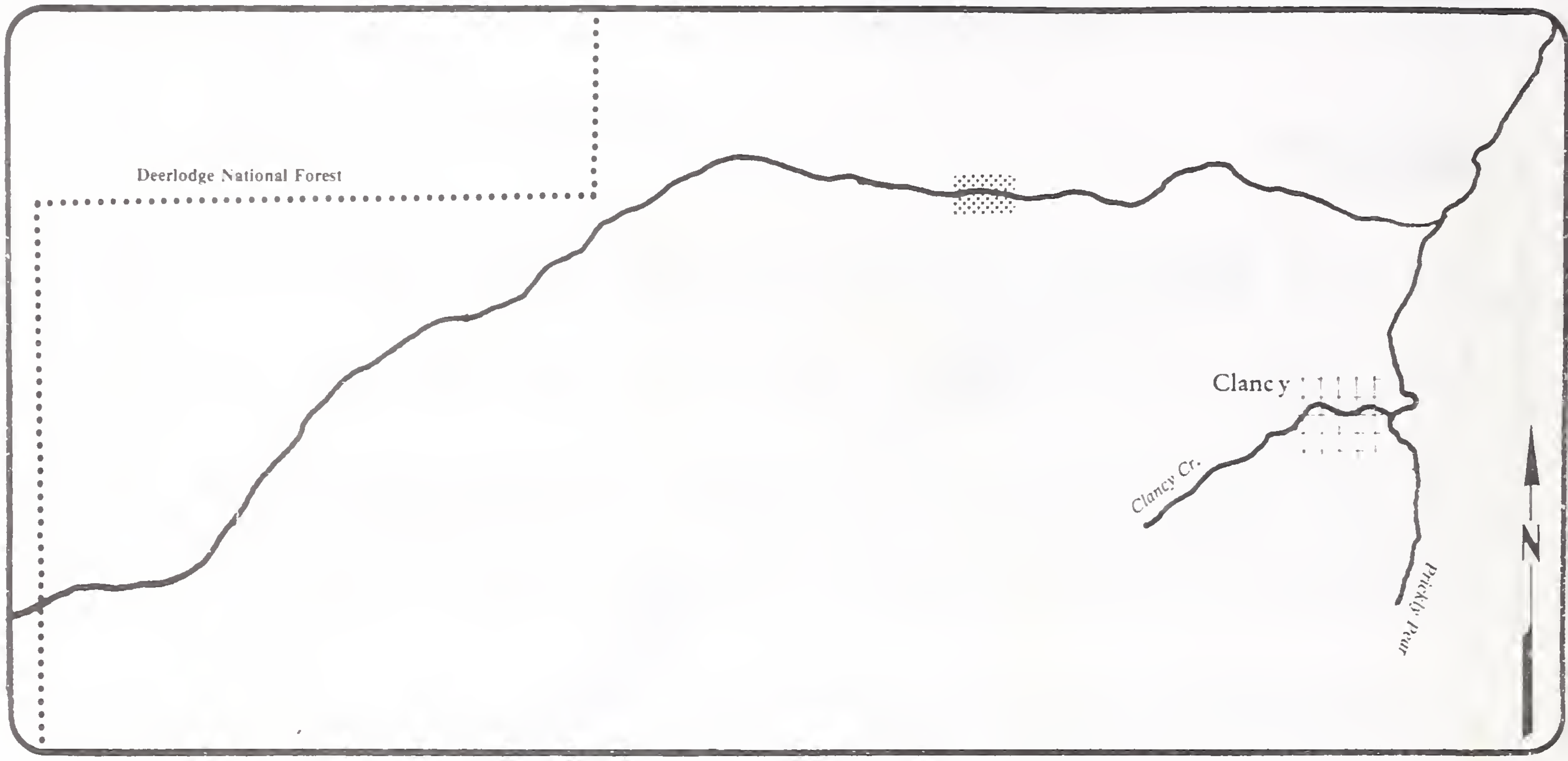
The lower section of Clancy Creek also has been altered by dredge mining, but not as severely as the middle section.

Possible corrective measures

Measures for reducing sedimentation from mining areas already have been discussed in the previous pages.

Actively eroding areas could require some attention at this time, but nature is already in the process of healing Clancy Creek by establishing new vegetation on most of the disturbed areas.

Figure 22



Lump Gulch

(aerial photos LG-1 through LG-13)

▨ Eroding banks

Lump Gulch

The inventory team felt it was only necessary to make a "windshield survey" of the creek in Lump Gulch because it is in relatively good condition. Man has had very little adverse impact on the stream. Periodic stops were made to confirm the condition of the stream and its banks.

There is a section that has some eroding banks. It's in a bottomland used for grazing or haying and is indicated on the map on the facing page. Vegetation along this stretch has been removed.

Possible corrective measures

We'd suggest giving the eroding section a chance to heal by changing some of the ranching practices there (see section on "Lake Helena to York Road" in this inventory).

It wouldn't hurt to plant some new vegetation there, too.

TABLE 17 Total findings of streambank inventory, August 1980

Physical features*	Prickly Pear Cr. Lk. Helena-E. Helena	Prickly Pear Cr. E. Helena-Golconda Cr.	Beavertown Creek	Corbin Creek	Spring Creek	Clancy Creek	Lump Gulch
Stream length, ft.	64,043	100,267	28,924	8,466	10,677	52,848	13,356
Channel alterations, ft.	5,952	121,170	21,065	5,149	19,083	47,918	
Streambank alterations:							
Rock riprap, ft.	14,471	22,692	20	259	558	538	
Jetties, number	2	3					
Car bodies, number	110	2		35			
Car bodies as riprap, ft.	548			398			
River gravel moved, ft.	139	6,554					
Other alterations, ft.	284	1,992		2,031			
Irrigation take-offs	15	1	1			1	
Irrigation return flows	8	7					
Other discharges	1						
Eroding banks, ft.	12,877	9,835	448	7,609	14,681	11,115	2,789
Bank mass wasting, ft.	5,669	1,076		1,633	70	807	100
Vertical non-eroding banks, ft.	219	100					
Debris jams, ft.	340	25		269			
Streambed material, ft.:							
Rubble-boulder							
Rubble-gravel	13,187	3,815	28,924			43,326	
Gravel	28,864	29,302					13,356
Sand-silt	13,894					4,283	
Mixed	8,097	67,150		8,466	10,677	5,239	
Channel obstructions, no.	39	9	5	1			

*Except for stream length, figures below include both right and left banks (for example, a 10,000-foot length of stream would have 20,000 feet of streambank).

Recommendations

Prickly Pear Creek and most of its tributaries are in poor physical condition, suffering from numerous Man-caused impacts. Some of these problems can be corrected with a minimum of effort, but others will take time, money and a great deal of cooperation.

It is the intent of this part of the report to highlight the impacts and suggest general corrective measures, not to prescribe specific remedies. Decisions should be made on a site-specific basis, with the involvement and cooperation of the landowners.

We do list below the order in which projects should be carried out. Our preference is to try non-structural riparian improvements first, because they require less planning time and money than structural improvements. Riparian improvements -- those that allow the streambanks to return to a "natural" well-vegetated condition -- possibly can be carried out using voluntary help from area residents and organizations.

In each category below, we rank the stream segments by severity of their problems. The worst stretches -- those in which improvements would have the most beneficial impact on the overall quality of the Prickly Pear -- are ranked 1. The lowest-priority area -- in which few improvements are really necessary -- is ranked 9.

Riparian improvements

1. Corbin and Spring Creek area
2. North of East Helena to Canyon Ferry Road
3. Placer tailings between Clancy and Jefferson City
4. Montana City to Clancy
5. York Road to Lake Helena
6. East Helena to Montana City
7. Clancy Creek -- placer tailings and upper mine area
8. Lump Gulch
9. Beavertown Creek

Structural improvements

1. Corbin Creek mining area*
2. Clancy to Montana City
3. Jefferson City to Clancy

* This highly-damaged area should be given the highest priority of all others in the Prickly Pear drainage. But reclamation of these abandoned mine lands is far beyond local funding sources. It may, however, be dealt with under the U.S. Interior Department's Abandoned Mine Lands Program. There's more on this area in Part III.

Part III

The Spring Creek drainage

Black sheep of the headwaters family

Water Quality Bureau
Department of Health and Environmental Sciences

July 1981

Contact person: Gary Ingman, 449-2406

Introduction

History of mining in the Colorado District

In July, 1862, a Mr. Hurlburt and a Negro companion found gold at Montana City, and by 1864 lode mining had begun in the Corbin and Spring Creek drainages (known as the Colorado District) 20 miles south of Helena. The first lead smelter was built at Gregory at the head of Clancy Creek in 1867. The completion of the Northern Pacific (Montana Central) Railroad to the area in 1883 gave added impetus to lode mining.

The Gregory Mine was most active during the early 1880s; the Alta Mine near Corbin, 1883-1893; the Comet Mine at the head of High Ore Creek in the Boulder River drainage, 1900; and the Minah, above Wickes, 1900-1901. A lead smelter at Wickes was operated from 1883-1893, then operations were transferred to East Helena. Total production for the district is estimated at $59 million, three-fourths of which was in silver and the rest was in gold, lead, copper and zinc (State of Montana, 1956)

Water quality problems

Prospectors became so intent on striking it rich that little consideration was paid to land and water. As the veins played out or became too difficult to pursue, the miners moved on to virgin territory. Tailings and settling ponds from long-abandoned hard-rock mines are a prominent feature in the Corbin and Spring Creek drainages southwest of Jefferson City. Nearly 100 years after peak mining activity the acid water, heavy metals and sediment from oxidized tailings continue to pollute streams and kill aquatic inhabitants. Groundwater also has been affected. Pollutants in Corbin Creek and Spring Creek are carried to Prickly Pear Creek and frequently are detectable in concentrations sufficient to impair aquatic life nearly to the stream's mouth, some 25 miles distant.

To communicate the serious nature of the problem, a discussion is necessary to explain how abandoned mine sites are capable of degrading water quality and the health of the biological components of streams. Three categories encompass the majority of hard-rock mine-related water quality problems: (1) acid mine drainage, (2) heavy metals and (3) sedimentation.

Acid mine drainage, a frequently encountered problem in the Spring Creek drainage, results when buried sulfide ore is exposed -- usually inside a mine shaft -- and comes into contact with oxygen and water. Oxidation of the sulfide compounds in the presence of water converts the sulfide to sulfate and releases acid, ferrous iron and the sulfate. Hydrolysis of the ferrous iron produces ferric hydroxide or hydrous ferric oxide. This rusty-colored substance -- called "yellowboy" -- can be seen coating the bottoms of Spring and Corbin Creeks. The acid released by this series of chemical reactions is a major cause of stream degradation. Sufficient concentrations, when reaching waterways, may directly poison aquatic life or may increase the toxicity of other chemical constituents in water. One such indirect method is through the dissolution of metals occurring in the tailings.

Solubility of heavy metals is pH dependent -- acidic conditions promote dissolution. As the acid is formed in mine shafts or in tailings, the metals are

are leached in proportion to their concentrations and their individual solubilities. These metals then may be carried to streams via surface runoff or mine discharges. Eventual seepage from the surface into groundwater is a possibility. Aquatic organisms come into contact with such metals as copper, zinc, lead, cadmium, arsenic and a host of others -- all potentially toxic. Even when exposed to sublethal concentrations, fish are capable of accumulating these metals in their tissues and they may become unsafe to eat. Some heavy-metal polluted water also is unsafe to drink.

The addition of unnatural amounts of silt to streams is another problem created by certain mining operations. Destruction of protective ground-covering vegetation and exposure of tailings piles to runoff pose the threat of accelerated erosion and excessive sediment contributions to nearby waterways. In severe cases, sediment may blanket stream bottoms, retarding plant growth, fish food production and fish spawning. Suspended sediment also may displace fish, reduce productivity of aquatic plants by decreasing light penetration, raise stream temperatures and lower the dissolved-oxygen content of the water.

Study design

A water-quality monitoring station on Spring Creek near its mouth was one of 12 located along Prickly Pear Creek in a 1979 Water Quality Bureau investigation to identify sources and quantities of pollutants. Sampling and field measurements were performed at each of the sites in February, June, August and November. Additional monitoring was performed in May 1980 to document water quality during peak flows resulting from snowmelt. The results of this study and the effects of pollutants contributed by Spring Creek to Prickly Pear Creek have been summarized in the Water Quality Overview (Part I of this report).

Spring Creek was identified as the most severe water pollution problem in the Prickly Pear drainage. Although many of the pollutants that enter Prickly Pear Creek via Spring Creek were measured, their sources in the Spring Creek drainage were not identified in Part I. But they are identified in this section of the report, and so are recommendations for their correction.

We had felt there were some limitations in the 1979 monitoring, so we undertook an intensive one-day sampling on Spring Creek on April 16, 1980. The creek and its tributaries, including mine drainages, were sampled at various points for mining-related pollutants, especially those that exceed water quality standards in the Prickly Pear below Spring Creek. Since pollutant loads discharged by Spring Creek are known to fluctuate with streamflow, all available discharge and water-quality data for sites within the Spring Creek drainage were used to substantiate and enhance the results of the April 1980 investigation. Frequently, these historical data-collection sites corresponded with the April 1980 monitoring locations.

In addition to the surface monitoring locations in the Spring Creek drainage, several wells in or near the town of Corbin were sampled. This investigation was spurred by reports that wells were contaminated by mine drainage.

All stations in the Spring Creek drainage for which data are available are described in Table 18, along with sampling dates. Specific locations are displayed in Figure 23 on Page 114.

TABLE 18 Water-quality monitoring stations in Spring Creek drainage

No.	Location	Twnshp	Range	Section	Dates sampled
Surface-water sites:					
01	Spring Creek near mouth at Jefferson City	7N	3W	6ACA	5-75; 6-77; 2,6,8,11-79; 4,5-80; 4-81
02	Spring Creek downstream of Corbin Cr. nr Corbin	7N	4W	1CAC	5-75; 6-77; 9-79; 4-80
03	Spring Creek upstream of Corbin Cr. nr Corbin	7N	4W	11AAA	6-77; 3-78; 4-80
04	Corbin Creek nr mouth at Corbin	7N	4W	1CCB	6-77; 3-78; 4-80
05	Corbin Cr. just downstream of Alta Mine drainage	7N	4W	2CDC	4-80
06	Corbin Cr. upstream from Alta Mine drainage	7N	4W	2CCC	7-74; 6-77; 4-80
07	Alta Mine drainage	7N	4W	2CCD	7-74; 9-79; 4-80
Additional historical-data sites:					
08	Drainage from Bertha tailings above Corbin	7N	4W	3DCD	9-79
09	Seep from base of Alta Mtn to drainage nr Wickes	7N	4W	9DCB	6-77
10	Seep from Washington Mines	7N	4W	17BDA	6-77; 9-79
11	Mine seep on Wood Chute Cr	7N	4W	18???	6-77
Domestic water supplies					
12	Fussel spring nr Corbin	7N	4W	2DCB	5-80
13	Leo Zitnick well in Corbin	7N	4W	2DDA	5-80
14	Bob Zitnick well in Corbin	7N	4W	2DDD	10-80
15.	Roane sump adjacent to Corbin Cr. in Corbin	7N	4W	2DDC	6-80

Parameters

Primary pollutants contributed by Spring Creek to Prickly Pear Creek are metals and sediment; therefore, monitoring efforts focused on these parameters. Four metals -- zinc, copper, manganese and iron -- occur in higher concentrations than other metals present in the creek. These four metals were used exclusively to trace sources of mining-related pollution when we conducted the April 1980 monitoring. We used two methods: (1) we measured metals that were dissolved in the water, and (2) we measured metals using the "total recoverable method" discussed in Part I of this report. The former method showed the sources of dissolved metals associated with acid mine drainage and more toxic to aquatic organisms. The latter method showed sources of metal-bearing sediments, like mine dumps and tailings. A downstream decrease in dissolved metals indicates buffering or neutralization of acids (with the resultant precipitation of metals), or dilution by groundwater or incoming tributaries.

Historical data for other metals such as arsenic, lead and cadmium were used where available. Nichlos et al. (1973) have defined acid mine drainage as water with a pH of less than 6, sulfate and iron levels greater than 75 and 0.5 milligrams per liter (mg/l) respectively, an alkalinity value of less than 20 mg/l, and a hardness of more than 150 mg/l. These parameters were used collectively to identify sources of acid mine drainage. Two or three of the parameters exceeding the acid drainage criteria at a particular site do not confirm such drainage, but the upstream presence of one is suggested.

Water hardness measurements also were necessary to determine the toxicity of such metals as zinc and copper to aquatic life. The degree of toxicity inflicted by many heavy metals is inversely proportional to hardness. The pH measurements are also important because they determine the solubility of the various metals.

Specific conductance was used as an approximator of the levels of dissolved solids -- the more dissolved material in a sample of water, the greater will be its ability to conduct electricity. Those dissolved materials may be common ions -- such as sulfates -- or they may be metals, or both. Regardless, a high specific conductance generally indicates pollution.

The parameters and applicable criteria are listed in Table 19. The rationale and criteria for protecting aquatic life and public health and aesthetics from metals, sediment and turbidity have been explained in the Water Quality Overview (Part I of this report).

Methods

The collection, handling and analysis of the more recent water samples generally followed "Standard Methods" (APHA et al. 1975) or equivalent EPA-sanctioned procedures (USEPA, 1976; USEPA, 1979). Earlier samples were analyzed according to methods acceptable at the time. Samples for measurement of dissolved metals were field-filtered through a .45-micron filter prior to analysis. Streamflows were measured by methods approved by the U.S. Geological Survey, except that historical flows occasionally were estimated.

The results of this investigation will be evaluated by site. For each site, data for all parameters will be presented in a tabular fashion. Preceding this will be a written assessment of conditions. The tables will include minimum, maximum and mean values for each parameter, as well as the number of criteria "exceedences" that were recorded. In determining aquatic-life exceedences (those values above the levels which begin to harm aquatic organisms), hardness values

TABLE 19 List of parameters and applicable criteria

Parameter	Criteria* Public health and aesthetics	 Protection of freshwater aquatic life	 Acid mine drainage definition
Streamflow (cfs)	--	--	--
Specific conductance (micromhos/cm^2@25°C)	--	--	--
pH	--	--	< 6
Alkalinity (mg/l as $CaCO_3$)	--	--	< 20
Hardness (mg/l as $CaCO_3$)	--	--	> 150
Sulfate (mg/l)	--	--	> 75
Turbidity (NTU)	5	--	--
Total suspended solids (mg/l)	--	25,80***	--
Iron (mg/l)	.30	--	$> .5$
Copper (mg/l)	1	**	--
Zinc (mg/l)	5	**	--
Manganese (mg/l)	.05	--	--
Lead (mg/l)	.05	**	--
Arsenic (mg/l)	.05	.44	--
Cadmium (mg/l)	.01	**	--

*Criteria for public health, aesthetics and protection of aquatic life are summarized in the water quality overview section of this report. Criteria defining acid mine drainage are from Nichlos, et al.

**Toxic effects of copper, zinc, lead and cadmium on aquatic life are dependent on water hardness. Formulas for determining toxicity are given in the water quality overview section.

***Fisheries can be maintained in waters that contain 25 to 80 mg/l suspended solids, but the yield of fish might be lower than in waters containing 25 mg/l or less. Waters carrying more than 80 mg/l suspended solids are unlikely to support good freshwater fisheries.

occasionally were not available for historical data. In such cases, the author arbitrarily applied a substantially higher hardness value -- based on the available mean value -- to calculate toxicity. In other words, if hardness data for a particular site resulted in a calculated mean hardness of 200 mg/l, the author used a hardness of 250 mg/l to calculate toxicity. In this manner, a safeguard was taken against making false statements concerning the number of exceedences. If there was any doubt as to whether metals criteria were exceeded, they were not reported as exceedences.

The study's primary objective was the determination of specific sources of pollutants in the Spring Creek drainage. To accomplish this, metals and sediment loads were calculated for each surface-water monitoring site where streamflow data were available. These figures are expressed in terms of the weight of a particular pollutant carried by a stream or mine discharge per unit of elapsed time (for example, pounds per day). Graphical presentations of sediment, copper, iron, zinc and manganese loads for each site will be given for the April 1980 data only, since this was the only date on which all the major sites were sampled in the Spring Creek drainage.

Sites for which only historical data were available will be handled separately. Because the historical data are very limited, individual results -- rather than ranges and means -- will be tabulated. But the same criteria that are used on other data will be used on the historical data. Because the author did not actually survey these additional sites, the interpretations will be speculative.

Domestic water supplies in the Corbin area that were sampled will also be evaluated separately. Criteria will be limited to public health and aesthetics and those parameters collectively indicating mine-related contamination -- hardness, sulfate, pH, alkalinity and the various metals.

One final note: Due to the overwhelming abundance of individual parameter measurements, only the ranges and means of parameter values are included in the tables for sites where more than one sampling was conducted. The reader is advised against drawing conclusions as to which sites carry the greatest pollutant loads and concentrations by using only the mean values. For some sites, such as Spring Creek near the mouth, one or more of the samples may have been taken under unusual conditions (like the flood of May 1975), whereas other sites located upstream were not sampled at that time. Such flood-related samples provided extremely high values which tend to skew the mean values well above levels commonly observed at the site. To arrive at conclusions, the author used the individual sets of data, which are on file at the Water Quality Bureau.

Results and interpretations

Site 01

Spring Cr. near mouth at Jefferson City

Although data for this site fail to delineate pollutant sources, types of pollutants and the ranges of pollutant loads contributed to Prickly Pear Creek are revealed. There clearly was a correlation between snowmelt runoff and pollutant loads; the highest metals and sediment levels always occurred in April through June. The worst water quality was documented during the maximum recorded flow -- in May 1975. At this time, Spring Creek discharged approximately 425 tons of sediment (enough dirt to fill four Burlington Northern coal cars) into the Prickly Pear in a 24-hour period! That included 9 tons of manganese, 6 tons of zinc, 4 tons of iron, 1.5 tons of lead, and nearly one-half ton of copper.

Sulfate, hardness and iron concentration exceeded the acid mine drainage criteria each time a sample was collected, but alkalinity and pH did not. Thus, Spring Creek near its mouth cannot be characterized as acid mine drainage, but the upstream presence of such drainage was suggested.

The primary pollutants shown to be exceeding the criteria for public health and aesthetics at this site were (in decreasing order of severity): manganese, turbidity, iron, lead, cadmium, zinc and arsenic. Parameters exceeding the limits for the protection of aquatic life were (in decreasing order of severity): cadmium, zinc, copper, sediment and lead.

Figures 25 and 26 and a review of the other available data show that much of the zinc, manganese and cadmium detected at this site were in the dissolved (and generally more toxic) form. Conversely, most of the iron (Fig. 24), copper (Fig. 27), lead and arsenic apparently were associated with suspended sediments and were not dissolved. Although metals that are bound to sediment particles may eventually find their way into the food chain and cause biological damage, they are not as immediate a threat to organisms as the dissolved metals.

Site No.: 01
Sample Location: Spring Creek near mouth at Jefferson City

					Number of Exceedences		
Parameter	Sample Size	Minimum Value	Mean	Maximum Value	Public Health and Aesthetics	Aquatic Life	Acid Mine Drainage
Streamflow (cfs)	9	2	5.5	20			
Specific conductance (umhos/cm^2 @ 25° C	10	419.1	1417	9500			
pH	9	3.1	7.1	8			1
Alkalinity (mg/l as $CaCO_3$)	7	22	42	67			0
Hardness (mg/l as $CaCO_3$)	8	179	223	267			8
Sulfate (mg/l)	9	134	194	251			9
Turbidity (NTU)	7	7.8	376	2500	7		
Total Suspended Solids (mg/l)	7	6.1	1160	7830		25 mg 5 80 mg 3	
Total Suspended Solids (lb/day)	7	120	120,000	840,000			
*TR Iron (mg/l)	10	.69	12.8	76	10		10
TR Iron (lb/day)	9	31	1000	8200			
TR Copper (mg/l)	10	.03	1.1	8	1	9	
TR Copper (lb/day)	9	1.4	100	860			
TR Zinc (mg/l)	10	.41	16.9	112	5	9	
TR Zinc (lb/day)	9	11	1400	12,000			
TR Manganese (mg/l)	10	.24	23.1	160	10		
TR Manganese (lb/day)	9	6.6	2000	17,000			
TR Lead (mg/l)	7	<.05	3.7	25	6	1	
TR Lead (lb/day)	7	<.78	390	2700			
TR Arsenic (mg/l)	7	<.001	.030	.096	1	0	
TR Arsenic (lb/day)	7	<.11	.72	2.1			
TR Cadmium (mg/l)	5	.010	.09	.376	4	5	
TR Cadmium (lb/day)	4	.19	10	40			

*TR refers to total recoverable analysis method. See Methods Section p. 3

Site 02

Spring Cr. downstream from Corbin Cr. near Corbin

In the nearly two miles between Sites 01 and 02 is located the "Corbin Flats" area. The relatively narrow valley through which Spring Creek flows was once the site of a series of mill-tailings ponds. Since the ponds were abandoned, Spring Creek has meandered its way back and forth across the valley, eroding the fine and unvegetated sands which once formed the beds of the ponds. The "flats" has long been suspected to be a critical source of sediment and metals in Spring Creek.

Water-quality data for Site 02, located at the upper end of the flats and below the confluence of Corbin Creek, are somewhat limited. Nonetheless, some conclusions can be drawn by comparing pollutant levels measured at Sites 01 and 02 on the same dates. Apparently during very high flows, as shown in the May 1975 data, the Corbin Flats does contribute substantial quantities of metals to Spring Creek. At that time -- between Sites 02 and 01 -- lead concentrations increased by 10 times, manganese by 3 times, and zinc by 2 times. However, monitoring during moderate to low flows showed either no significant difference in pollutant concentrations between Sites 02 and 01 (as was the case in June 1979) or an actual, though slight, decrease below Corbin Flats (as documented in April 1980).

Significantly, the available data failed to show an increase in suspended sediment loads in Spring Creek below Corbin Flats. In fact, a very definite decrease was noted. It would not be difficult to imagine Spring Creek acting as a sediment trap during low flows because of its low gradient in this reach. But during very high flows, there will be sediment contributions from the highly erosive tailings-pond materials and no net losses. Most likely, the Corbin Flats contributes a substantial sediment load during high flows and in certain areas. Either this additional load is offset by the settling of some of the incoming load, or the 1975 data are in error.

Public health and aesthetics criteria were routinely exceeded for turbidity, iron, manganese, zinc and cadmium. Arsenic, lead and copper exceeded criteria at a lesser frequency. Zinc, cadmium, copper, sediment and, occasionally, lead posed threats to aquatic life. Most of the manganese and zinc at this site were dissolved. Iron and copper were primarily bound to sediment particles.

The very poor quality of water in Spring Creek at this site was substantiated by an examination of the resident fishery by Water Quality Bureau and Department of Fish, Wildlife and Parks personnel in October 1980. Although good numbers of brook and rainbow trout were found in Spring Creek above Corbin Creek (Site 03), only two were collected in 150 yards of Spring Creek at Site 02. And there's a good possibility that these two trout drifted downstream into Site 02 from the Site 03 area, which was inventoried first.

ite No.: 02
ample Location: Spring Creek downstream from Corbin Creek

arameter	Sample Size	Minimum Value	Mean	Maximum Value	Number of Exceedences: Public Health and Aesthetics	Number of Exceedences: Aquatic Life	Number of Exceedences: Acid Mine Drainage
treamflow (cfs)	3	2.5	8.4	20			
pecific conduc-ance (umhos/cm^2 25° C	3	450	658.7	1050			
H	3	6.5	6.9	7.2			0
lkalinity (mg/l as CaCO$_3$)	1	23	23	23			0
ardness (mg/l as CaCO$_3$)	1	192	192	192			1
Sulfate (mg/l)	2	153	165	177			2
Turbidity (NTU)	2	24	1612	3200	2		
Total Suspended Solids (mg/l)	2	25.8	5928	11,830		25 mg 2 80 mg 1	
Total Suspended Solids (lb/day)	2	390	64000	1,300,000			
*TR Iron (mg/l)	4	.64	19.5	71	4		4
TR Iron (lb/day)	3	36	2600	7700			
TR Copper (mg/l)	4	.03	3.6	14	1	3	
TR Copper (lb/day)	3	1.9	500	1500			
TR Zinc (mg/l)	4	.89	17.8	60	3	4	
TR Zinc (lb/day)	3	70	2200	6500			
TR Manganese (mg/l)	4	1.19	17	53	4		
TR Manganese (lb/day)	4	90	1700	5700			
TR Lead (mg/l)	3	<.05	.73	2.2	1	1	
TR Lead (lb/day)	2	<.67	120	240			
TR Arsenic (mg/l)	2	.010	.180	.350	1	0	
TR Arsenic (lb/day)	2	.13	19	38			
TR Cadmium (mg/l)	2	.013	.126	.238	2	2	
TR Cadmium (lb/day)	2	.18	13	26			

*TR refers to total recoverable analysis method. See Methods Section p. 3

Site 03

Spring Cr. upstream from Corbin Cr. near Corbin

Spring Creek originates about two miles upstream from this monitoring site, where it bubbles from a meadow in a series of springs. Interpretations of water-quality data collected at Site 03 eliminate this stream reach as the source of pollutants that are found lower down on Spring Creek. Water quality here is excellent. Dissolved and total recoverable metals, sediment and dissolved minerals (they're determined by specific conductance) generally occurred in low concentrations. In one out of three samplings, iron and manganese slightly exceeded drinking-water criteria. But these metals are important in drinking-water supplies only from the standpoint of staining and taste problems. They are not particularly toxic to humans or aquatic life.

Acid mine drainage problems were not indicated and the other criteria were not exceeded here, a fact that will be appreciated by the Corbin residents who routinely use Spring Creek as their residential water supply.

On rare occasions--such as during heavy runoff--overland flow and mine drainage from the Wickes area reach the headwaters of Spring Creek and temporarily contaminate it. During these times, Corbin residents are forced to haul water. Apparently, however, the biological effects of such runoff are less than acute, since this reach of Spring Creek supports a healthy resident fishery.

The severe drop in Spring Creek's water quality between this site and Site 02 (just downstream of Corbin Creek) suggests that Corbin Creek is the major source of pollutants.

Site No.: 03
Sample Location: Spring Creek upstream from Corbin Creek

Parameter	Sample Size	Minimum Value	Mean	Maximum Value	Number of Exceedences		
					Public Health and Aesthetics	Aquatic Life	Acid Mine Drainage
Streamflow (cfs)	3	1	2.6	3.4			
Specific conductance (umhos/cm^2 @ 25° C	3	337	369.7	388			
pH	2	8.2	8.5	8.8			0
Alkalinity (mg/l as $CaCO_3$)	1	30	30	30			0
Hardness (mg/l as $CaCO_3$)	1	137	137	137			0
Sulfate (mg/l)	3	115	124	137			3
Turbidity (NTU)	1	.5	.5	.5	0		
Total Suspended Solids (mg/l)	1	5.3	5.3	5.3		25 mg 0 80 mg 0	
Total Suspended Solids (lb/day)	1	97	97	97			
*TR Iron (mg/l)	3	.11	.22	.39	1		0
TR Iron (lb/day)	3	2	2.3	2.8			
TR Copper (mg/l)	3	<.01	.01	.01	0	0	
TR Copper (lb/day)	3	<.05	.12	.18			
TR Zinc (mg/l)	3	.04	.07	.12	0	0	
TR Zinc (lb/day)	3	.65	.76	.92			
TR Manganese (mg/l)	3	.03	.05	.09	1		
TR Manganese (lb/day)	3	.48	.52	.55			
TR Lead (mg/l)	1	<.05	<.05	<.05	0	0	
TR Lead (lb/day)	1	<.89	<.89	<.89			
TR Arsenic (mg/l)	2	.019	.021	.023	0	0	
TR Arsenic (lb/day)	2	.12	.23	.34			
TR Cadmium (mg/l)	2	<.001	<.005	<.005	0	0	
TR Cadmium (lb/day)	2	<.005	<.09	<.09			

*TR refers to total recoverable analysis method. See Methods Section p. 3

Site 04

Corbin Cr. near mouth at Corbin

Most of the mine-related water pollutants detected in lower Spring Creek clearly originated from within the Corbin Creek drainage, despite its very small discharge. Yellowboy was observed staining the Corbin Creek streambottom throughout its length and extending into the Spring Creek channel.

Metals and sediment loads and concentrations were greater at this site than at any of those previously discussed, on the two occasions that monitoring was performed at all the sites on the same day. Additionally, each time this site was monitored, all acid mine drainage criteria were met. Most of the zinc, copper and manganese -- and a substantial amount of iron -- were in the dissolved form at the time of the April 1980 monitoring, further confirming the presence of acid mine drainage.

Corbin Creek was probably the source of those acid mine drainage indicators that showed up downstream in Spring Creek (at Sites 01 and 02).

Except for lead, all of the public health and aesthetics criteria were exceeded routinely in Corbin Creek near its mouth. Sediment, copper, zinc and cadmium exceeded limits for the protection of aquatic life each time those parameters were monitored; their combined effects were clearly sufficient to explain the biological sterility observed at this site. Lead and arsenic, however, did not pose threats to aquatic life when samples were taken.

Site No.: 04
Sample Location: Corbin Creek near mouth at Corbin

					Number of Exceedences		
Parameter	Sample Size	Minimum Value	Mean	Maximum Value	Public Health and Aesthetics	Aquatic Life	Acid Mine Drainage
Streamflow (cfs)	3	.3	.6	1			
Specific conductance (umhos/cm^2 @ 25° C	3	1671	1953.6	2355.7			
pH	3	2.9	3	3.1			3
Alkalinity (mg/l as $CaCO_3$)	3	1.27 Acidity	.95 Acidity	.78 Acidity			3
Hardness (mg/l as $CaCO_3$)	1	452	452	452			1
Sulfate (mg/l)	3	829	974	1210			3
Turbidity (NTU)	1	280	280	280	1		
Total Suspended Solids (mg/l)	1	291	291	291		25 $\frac{mg}{l}$ ¦ 80 $\frac{mg}{l}$	
Total Suspended Solids (lb/day)	1	470	470	470			
*TR Iron (mg/l)	3	47.9	72	118	3		3
TR Iron (lb/day)	3	77	270	640			
TR Copper (mg/l)	3	3	4.2	6.2	3	3	
TR Copper (lb/day)	3	5.5	15	33			
TR Zinc (mg/l)	3	61	83.7	115	3	3	
TR Zinc (lb/day)	3	99	240	400			
TR Manganese (mg/l)	3	76.2	110	155	3		
TR Manganese (lb/day)	3	120	320	530			
TR Lead (mg/l)	1	<.05	<.05	<.05	0	0	
TR Lead (lb/day)	1	<.10	<.10	<.10			
TR Arsenic (mg/l)	2	.025	.200	.374	1	0	
TR Arsenic (lb/day)	2	.05	1	2			
TR Cadmium (mg/l)	2	.287	.294	.300	2	2	
TR Cadmium (lb/day)	2	.60	1.1	1.6			

*TR refers to total recoverable analysis method. See Methods Section p. 3

Site 05

Corbin Cr. just downstream from Alta Mine drainage

Data for this site were limited to the results of the April 1980 survey. Water quality was significantly worse here than at Site 04, just one mile downstream. All parameters for which data were available greatly surpassed the applicable criteria, including the acid mine drainage characteristics.

Metals concentrations and loads exceeded all the previously examined sites by nearly twice. Ninety or more percent of the manganese, copper and zinc and substantial amounts of iron were dissolved, indicating the influence of acid. And the sediment loads measured at this site in April 1980 greatly exceeded loads at all other locations monitored at that time (Figure 23). Thus, it is clear that upper Corbin Creek was the major source of metals and sediment in the Spring Creek drainage in mid-April, 1980.

Between Site 05 and 04, sulfate, hardness, metals and dissolved solids concentrations decreased markedly. Conversely, the pH increased and -- although no alkalinity was detectable at either site -- acidity was reduced. Apparently, the acid mine drainage at Site 05 was neutralized partially while flowing downstream through contact with streambed rock. As the acidic conditions were reduced somewhat, precipitation of dissolved metals and other minerals occurred. Figures 24 through 27 depict the marked reduction in dissolved iron, zinc, copper and manganese between Sites 05 and 04.

In a similar fashion, sediment loads decreased by about 600 pounds per day (as shown in Fig. 23), apparently through deposition within the stream channel. Accompanying this sediment loss was the reduction by about 30 pounds per day of suspended, non-dissolved iron.

Although the natural recovery of Corbin Creek between Site 05 and the stream's mouth was significant, water quality at the mouth remained exceedingly poor. And the pollutants deposited instream between the two sites remained ready to be carried downstream by higher flows, such as those of May, 1981.

Site No.: 05

Sample Location: Corbin Creek just downstream from Alta Mine drainage

					Number of Exceedences		
Parameter	Sample Size	Minimum Value	Mean	Maximum Value	Public Health and Aesthetics	Aquatic Life	Acid Mine Drainage
Streamflow (cfs)	1	.3	.3	.3			
Specific conductance (umhos/cm^2 @ 25° C	1	2620	2620	2620			
pH	1	2.7	2.7	2.7			1
Alkalinity (mg/l as $CaCO_3$)	1	2.06 Acidity	2.06 Acidity	2.06 Acidity			1
Hardness (mg/l as $CaCO_3$)	1	561	561	561			1
Sulfate (mg/l)	1	1306	1306	1306			1
Turbidity (NTU)	1	440	440	440	1		
Total Suspended Solids (mg/l)	1	662	662	662		25 mg/l 80 mg/l	
Total Suspended Solids (lb/day)	1	1100	1100	1100			
*TR Iron (mg/l)	1	101	101	101	1		1
TR Iron (lb/day)	1	160	160	160			
TR Copper (mg/l)	1	5.07	5.07	5.07	1	1	
TR Copper (lb/day)	1	8.2	8.2	8.2			
TR Zinc (mg/l)	1	106	106	106	1	1	
TR Zinc (lb/day)	1	170	170	170			
TR Manganese (mg/l)	1	148	148	148	1		
TR Manganese (lb/day)	1	240	240	240			
TR Lead (mg/l)	0						
TR Lead (lb/day)	0						
TR Arsenic (mg/l)	0						
TR Arsenic (lb/day)	0						
TR Cadmium (mg/l)	0						
TR Cadmium (lb/day)	0						

*TR refers to total recoverable analysis method. See Methods Section p. 3

Site 06

Corbin Cr. upstream from Alta Mine drainage

Water quality in Corbin Creek upstream of the Alta Mine drainage was much better than in lower Corbin Creek, and -- in some respects -- better than in Spring Creek near its mouth.

During the April 1980 monitoring, zinc and manganese concentrations were much lower than at any of the sites thus far examined, except for Spring Creek upstream from Corbin Creek. Although acid mine drainage criteria were exceeded for hardness, sulfate and iron, the alkalinities and pH's were consistently high (the reverse of acid drainage criteria). This seemed to indicate the presence of acid mine drainage somewhere upstream and, as we shall see, historical data confirm this conclusion, even though yellowboy was not present at this site.

The worst problem here was a high metal-bearing sediment load. The Corbin Creek headwaters -- upstream of the Alta Mine discharge -- apparently was the area of greatest sediment contribution in the Spring Creek drainage. This is not hard to understand. The topography adjacent to the creek near here consisted of denuded tailings piles, a washed-out tailings pond, and some very extensive, actively sloughing cutbanks. The small stream was quite turbid.

Associated with the sediment were appreciable concentrations of copper, manganese and iron. In fact, it appears that in April 1980, this site was the single most important source of total recoverable iron and the second most important source of total recoverable copper in the Spring Creek drainage. Figures 24, 25 and 27 show that almost none of the copper and iron was dissolved. Thus, most of the metals were in the form of sediment complexes.

Site No.: 06
Sample Location: Corbin Creek upstream from Alta Mine drainage

					Number of Exceedences		
Parameter	Sample Size	Minimum Value	Mean	Maximum Value	Public Health and Aesthetics	Aquatic Life	Acid Mine Drainage
Streamflow (cfs)	2	.04	.10	.15			
Specific conductance (umhos/cm^2 @ 25° C	2	586	649	712.1			
pH	2	7.5	7.7	7.9			0
Alkalinity (mg/l as $CaCO_3$)	1	60	60	60			0
Hardness (mg/l as $CaCO_3$)	1	273	273	273			1
Sulfate (mg/l)	2	215	221	227			2
Turbidity (NTU)	1	470	470	470	1		
Total Suspended Solids (mg/l)	1	965	965	965		25 mg/l 80 mg/l	
Total Suspended Solids (lb/day)	1	780	780	780			
*TR Iron (mg/l)	3	.81	89.9	268	3		3
TR Iron (lb/day)	2	.19	110	220			
TR Copper (mg/l)	3	.26	1.48	3.72	1	3	
TR Copper (lb/day)	2	.06	1.5	3			
TR Zinc (mg/l)	3	.22	.73	1.40	0	1	
TR Zinc (lb/day)	2	.13	.16	.18			
TR Manganese (mg/l)	3	.29	.64	1.05	3		
TR Manganese (lb/day)	2	.07	.46	.85			
TR Lead (mg/l)	1	<.05	<.05	<.05	0	0	
TR Lead (lb/day)	0						
TR Arsenic (mg/l)	2	.001	.001	.001	0	0	
TR Arsenic (lb/day)	1	<.01	<.01	<.01			
TR Cadmium (mg/l)	2	.010	.014	.018	1	2	
TR Cadmium (lb/day)	1	<.01	<.01	<.01			

*TR refers to total recoverable analysis method. See Methods Section p. 3

Site 07

Alta Mine drainage

The Alta Mine drainage originates about one mile southwest of upper Corbin Creek. It emerges from an adit on Alta Mountain. The source of the discharge is groundwater intersected by one or more of the many tunnels of the inactive mine. After leaving the adit, the drainage flows a short way, then goes underground. But it resurfaces at the base of a large tailings dump. The flow then continues unobstructed to Corbin Creek. It is likely that pollutants detectable in the drainage originate both inside the mine and in the tailings pile.

Despite its small discharge, the Alta Mine drainage was without question the single most important source of metals and acid in Spring Creek. pH values as low as 2.4 (very acidic) and sulfate concentrations nearly double those recorded elsewhere were detected in the Alta discharge. The hardness value also was the highest observed. In April 1980, the less than 70-gallon-per-minute discharge poured approximately 250 pounds of manganese, 180 pounds of zinc, 140 pounds of iron, 130 pounds of sediment and more than 5 pounds of copper per day into Corbin Creek! The metals were nearly 100 percent dissolved.

All the applicable criteria were exceeded at Site 07. Arsenic and lead, however, were monitored only in 1974 and 1979, respectively, and did not exceed criteria.

Snowmelt runoff was below normal in April 1980 and peak flows in the Corbin Creek drainage did not materialize. The author feels that documented metal loads would be greatly surpassed under heavy runoff conditions because of increased leaching of the Alta Mine tailings at the head of this drainage. Braico and Botz (1974) and Traynor (1969) concluded that the seasonal fluctuation in the quality of this discharge was a result of increased runoff and leaching in the spring of the year. Load calculations for Spring Creek below Corbin Creek in May 1975 surpassed April 1980 loads in the Alta Mine discharge by 278, 54, 35 and 23 times for manganese, zinc, iron, and copper respectively. The major portion of these metals measured in 1975 may very well have originated in the Alta Mine discharge.

A comparison of the metals load in the Alta Mine drainage in April 1980 with the loads measured in Corbin Creek above and below the Alta discharge (Sites 06 and 05) on the same day reveals the following: As the acidic Alta discharge flowed into Corbin Creek, some of the acid was neutralized by Corbin Creek's alkalinity. The resulting pH increase caused precipitation of some of the dissolved zinc, manganese and iron that came from the Alta. However, all of the Alta's dissolved copper remained in solution after it mixed with Corbin Creek. And a drop in Corbin Creek's pH from Site 06 to Site 05 caused most of the creek's particulate copper to dissolve also. Thus, the Alta Mine drainage is not only a critical metals source,

Site No.: 07
Sample Location: Alta Mine drainage

Parameter	Sample Size	Minimum Value	Mean	Maximum Value	Number of Exceedences Public Health and Aesthetics	Number of Exceedences Aquatic Life	Number of Exceedences Acid Mine Drainage
Streamflow (cfs)	3	.01	.06	.15			
Specific conductance (umhos/cm^2 @ 25^0 C	1	4280	4280	4280			
pH	2	2.4	4	5.5			2
Alkalinity (mg/l as $CaCO_3$)	1	3.75 ------	3.75 -Acidity	3.75 -----			1
Hardness (mg/l as $CaCO_3$)	1	868	868	868			1
Sulfate (mg/l)	1	2550	2550	2550			1
Turbidity (NTU)	1	385	385	385	1		
Total Suspended Solids (mg/l)	2	165	1947	3729		25 mg 2 80 mg 2	
Total Suspended Solids (lb/day)	2	130	180	220			
*TR Iron (mg/l)	3	160	297.5	558.6	3		3
TR Iron (lb/day)	3	8.8	60	140			
TR Copper (mg/l)	2	.75	3.72	6.70	1	2	
TR Copper (lb/day)	2	.04	2.7	5.4			
TR Zinc (mg/l)	3	226	349.7	493.2	3	3	
TR Zinc (lb/day)	3	18	76	180			
TR Manganese (mg/l)	3	307	485.7	670	3		
TR Manganese (lb/day)	3	26	104	250			
TR Lead (mg/l)	1	<.05	<.05	<.05	0	0	
TR Lead (lb/day)	1	<.01	<.01	<.01			
TR Arsenic (mg/l)	1	.03	.03	.03	0	0	
TR Arsenic (lb/day)	1	<.01	<.01	<.01			
TR Cadmium (mg/l)	1	.32	.32	.32	1	1	
TR Cadmium (lb/day)	1	.02	.02	.02			

*TR refers to total recoverable analysis method. See Methods Section p. 3

it also dissolves metals from other sources by lowering pH.

In summary, the Alta Mine drainage contained the worst quality water and was the greatest single source of heavy-metal loads in the Spring Creek drainage when examined in April 1980.

Site 08

Drainage from Bertha tailings dump

Several small-volume seeps enter upper Corbin Creek at points upstream of Site 06. Site 06, if you recall, displayed a sediment problem and moderately low levels of dissolved zinc and maganese. Other metals present primarily were associated with sediment. In 1979, the Department of State Lands sampled one of the small seeps originating at the base of the extensive Bertha Mine tailings dump above Site 06.

Although few parameters were analyzed during the DSL testing, the seep was shown to have the characteristics of acid mine drainage (low pH and high iron content). Zinc and manganese were present in high concentrations, but the loads contributed to Corbin Creek were insignificant because of the small discharge.

Indications of acid drainage were present downstream from the Bertha seeps, but the alkalinity in Corbin Creek apparently neutralized the acid and caused precipitation of most metals. The relatively low dissolved zinc and manganese concentrations at Site 06 may have originated from the seeps, but it is likely that the sediment and associated metals did not.

Compared to other problems in the Corbin Creek drainage, the drainage from the Bertha tailings dump (Site 08) doesn't cause much concern.

Site 09

Seep from base of Alta Mountain

This seep originated on the south side of Alta Mountain and flowed into an unnamed, intermittent tributary which flows into the headwaters of Spring Creek only during excessive runoff. Normally, the tributary dries up or seeps into the ground somewhere just north of Wickes.

Pedersen monitored this discharge during his Boulder Batholith study in 1977. Although the available data suggest an acid mine seep, only iron and manganese concentrations were excessive. Due to the very small size of the discharge (1 gallon per minute), effects on receiving streams would most likely be minimal.

Compared to other problem areas in the Spring Creek drainage, this site, too, was of minimal concern.

Site 10

Seep from Washington mine

This mine discharge, located northwest of Wickes, flowed through a series of washed-out tailings ponds and entered another unnamed, intermittent tributary above the headwaters of Spring Creek (Pedersen, 1977). Like Site 09, rarely would this seep discharge into Spring Creek.

On the two occasions that this seep was sampled (Pedersen in 1977, DSL in 1979), pH's were highly variable and the seep carried elevated levels of iron, zinc and manganese. In 1977, arsenic levels were detectable.

The author feels that this site may exceed the two previously discussed sites in importance, but it should take a very low priority when compared to the other sources of pollutants which consistently reach perennial surface waters.

Site 11

Mine seep on Wood Chute Cr.

The mine seep on Wood Chute Creek due west of Wickes was sampled once -- by Pedersen in 1977. The discharge rate at the time of sampling was rather large compared to the other historical-data sites. Water quality also was the worst.

Although data did not suggest an acid drainage situation, iron, zinc, manganese, lead and arsenic levels were excessive. Fortunately, like other sites, this seep flowed underground within a quarter mile of its origin and never reached Spring Creek.

If reclamation efforts were attempted, this site should be given attention over the other three historical-data sites.

Site No.: 08 through 11
Sample Location: Additional historical-data sites

Parameter	Site Number					Number of Exceedences		
	08	09	10a	10b	11	Public Health and Aesthetics	Aquatic Life	Acid Mine Drainage
Streamflow (cfs)	.01	<.01	.11	.16	.30			
Specific conductance (umhos/cm^2 @ 25^0 C		818	654		1145			
pH	5	6	7.2	4.5	7			2
Alkalinity (mg/l as $CaCO_3$)								
Hardness (mg/l as $CaCO_3$)								
Sulfate (mg/l)		445	200		675			3
Turbidity (NTU)								
Total Suspended Solids (mg/l)								
Total Suspended Solids (lb/day)								
*TR Iron (mg/l)	2.32	37	5.9	3.17	17	5		5
TR Iron (lb/day)	.14	.44	3.5	2.7	27			
TR Copper (mg/l)	.15	<.01	<.01	.01	.23	0	2	
TR Copper (lb/day)	.01	<.01	<.01	.01	.37			
TR Zinc (mg/l)	2.92	.72	3.1	1.66	24	1	5	
TR Zinc (lb/day)	.18	<.01	1.9	1.4	39			
TR Manganese (mg/l)	5.50	18	2.9	3.22	13	5		
TR Manganese (lb/day)	.33	.22	1.7	2.7	21			
TR Lead (mg/l)	.07	<.05	<.05	<.05	1.6	2	0	
TR Lead (lb/day)	<.01	<.01	<.03	<.04	2.6			
TR Arsenic (mg/l)		<.004	.18		5.1	2	1	
TR Arsenic (lb/day)		<.01	.11		8.2			
TR Cadmium (mg/l)		<.005	.005		.12	1	1	
TR Cadmium (lb/day)		<.01	<.01		.19			

*TR refers to total recoverable analysis method. See Methods Section p. 3

Sites 12—15

Wells, spring and sump in Corbin area

Of the four domestic water supplies that were sampled in the Corbin area, two were relatively deep wells, one was a spring, and one was a sump located next to Corbin Creek.

A review of the chemical data showed Roane's sump (Site 15) to be, not suprisingly, the most contaminated water supply. The water was nothing more than Corbin Creek water which had been allowed to percolate through a layer of alluvium, removing much of the suspended solids and non-dissolved metals. The owner at first had planned on using the supply for household purposes other than drinking. However, the acidic water corroded the iron plumbing, which soon became useless.

George Fussell's spring (Site 12), located just above Corbin on a hillside overlooking Corbin Creek, showed no evidence of mine-related contamination. Although hardness and sulfate values slightly exceeded mine drainage criteria, it was most likely a natural condition. Metals and specific conductance levels were low and pH and alkalinity normal.

Leo and Bob Zitnik's wells (Site 13 and 14), despite their depths below the Corbin Creek drainage, seemed to show indications of mine-caused contamination. Specific conductance, hardness and sulfate were relatively high. Zinc was extremely high for uncontaminated groundwater, although below drinking-water limits. The iron concentration was substantial in Leo Zitnick's well and exceeded taste and staining thresholds.

Although threats to public health were not indicated in any of the drinking-water supplies that were examined (Roane's sump is not used for drinking), evidence of mine-related contamination in two of the other three sources is apparent. Other wells in Corbin have been abandoned in the past, reportedly because of mine-related pollution. Therefore, it seems safe to conclude that the impacts of mine drainage in the Corbin Creek area extend beyond contaminated surface waters.

Site No.: 12 through 15

Sample location: Domestic Water Supplies

Parameter	Site Number 12	13	14	15	Number of Exceedences: Public Health and Aesthetics	Aquatic Life	Acid Mine Drainage
Well depth	NA	93'	45'	14'			
Specific conductance (umhos/cm^2 @ 25^0 C	403	720	696	1282			
pH	7.9	7.9	7.2	4.3			1
Alkalinity (mg/l as $CaCO_3$)	93	110	88	0			1
Hardness (mg/l as $CaCO_3$)	171	348	334	535			4
Sulfate (mg/l)	105	247	251	675			4
Turbidity (NTU)							
Total Suspended Solids (mg/l)							
Total Suspended Solids (lb/day)							
*TR Iron (mg/l)	.01	.55	.16	<.01	1		1
TR Iron (lb/day)							
TR Copper (mg/l)	.03	<.01	<.01	1.55	1		
TR Copper (lb/day)							
TR Zinc (mg/l)	.02	1.47	2.56	43.76	1		
TR Zinc (lb/day)							
TR Manganese (mg/l)	<.01	.01	<.01	34.93	1		
TR Manganese (lb/day)							
TR Lead (mg/l)							
TR Lead (lb/day)							
TR Arsenic (mg/l)	<.001	<.001	<.001	<.001	0		
TR Arsenic (lb/day)							
TR Cadmium (mg/l)							
TR Cadmium (lb/day)							

*TR refers to total recoverable analysis method. See Methods Section p. 3

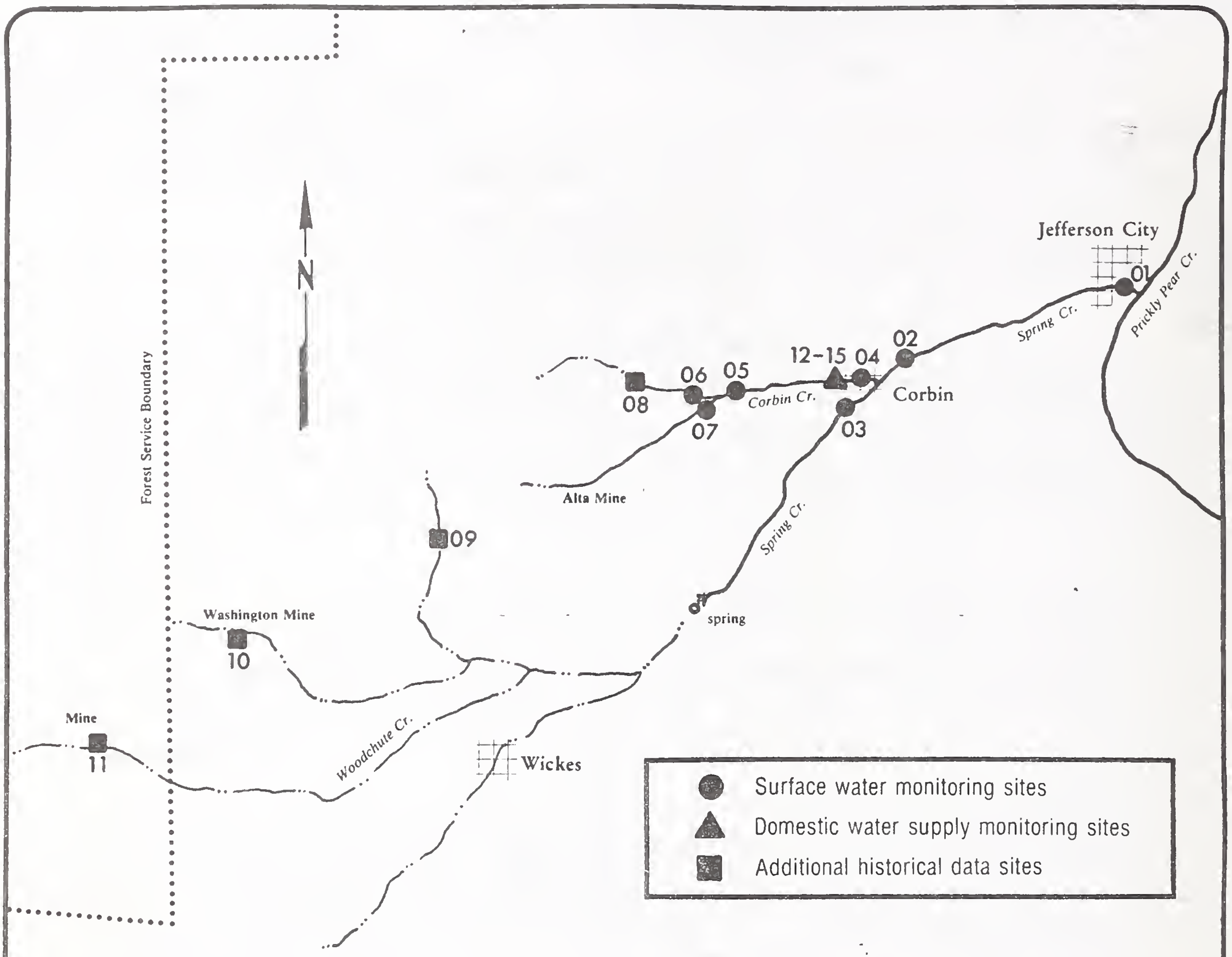
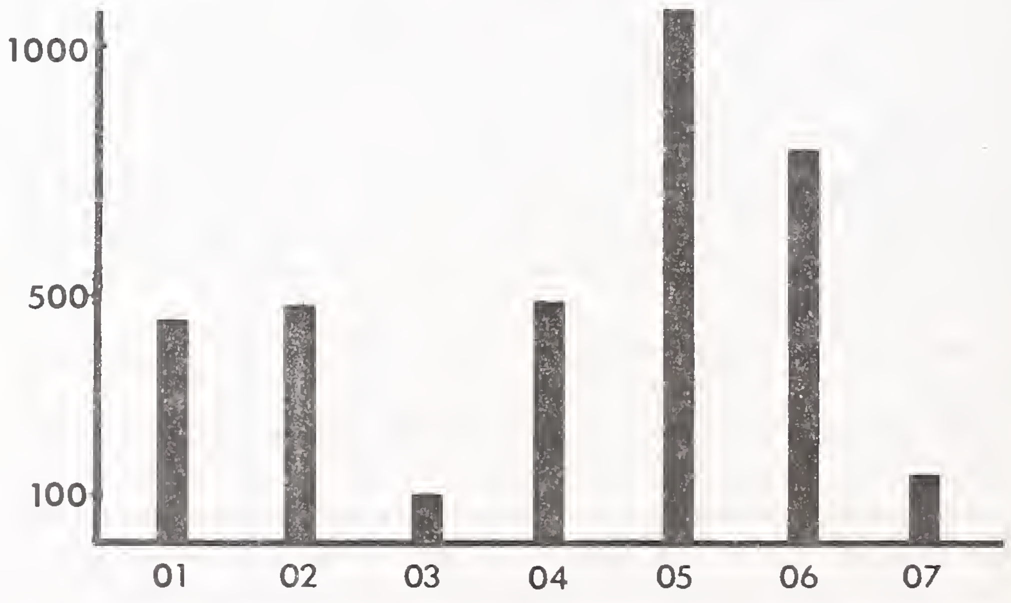


Figure 23

Total suspended solids (load in lb/day)

April 16, 1980



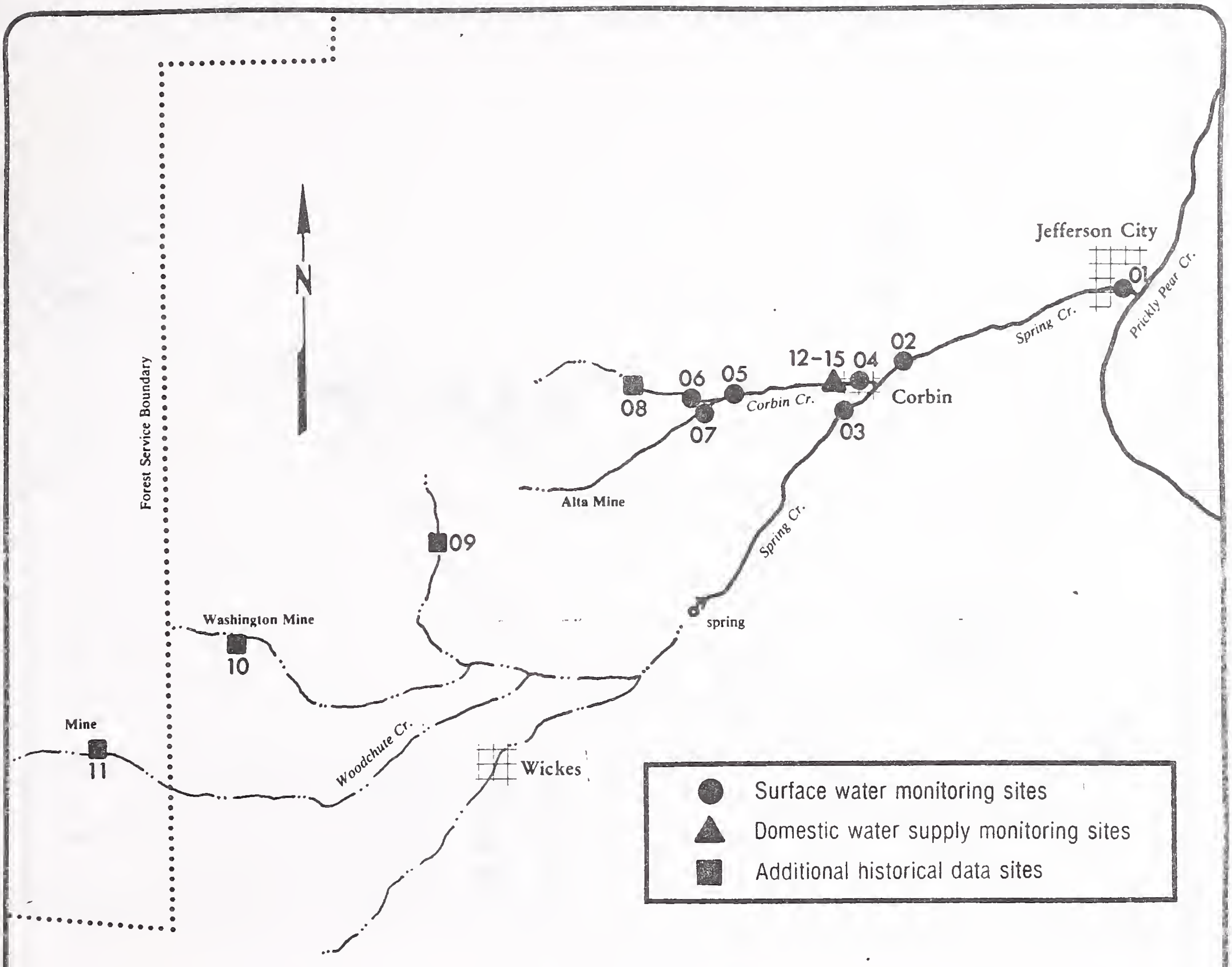
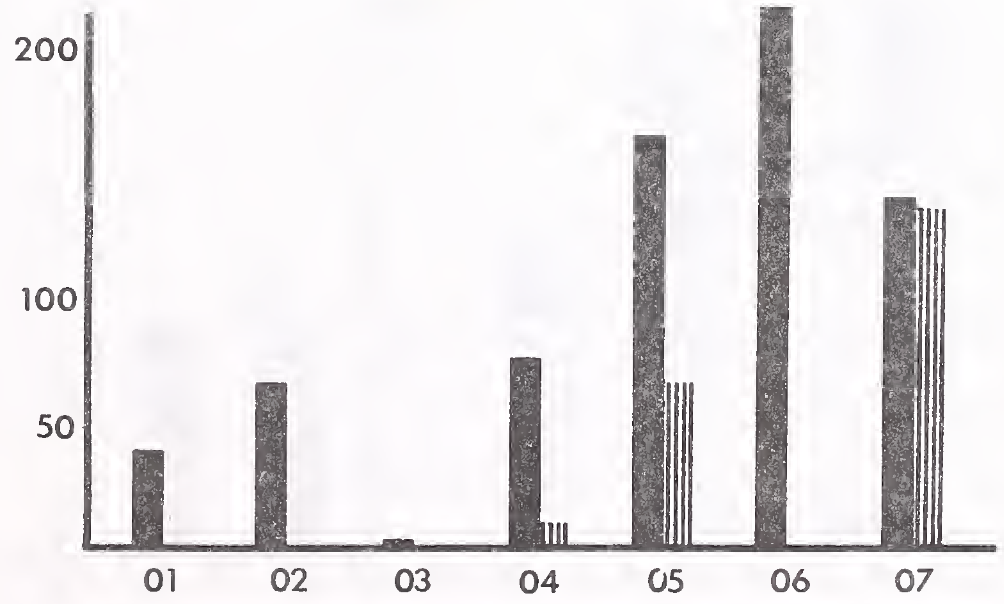


Figure 24

Iron
(load in lb/day)



April 16, 1980

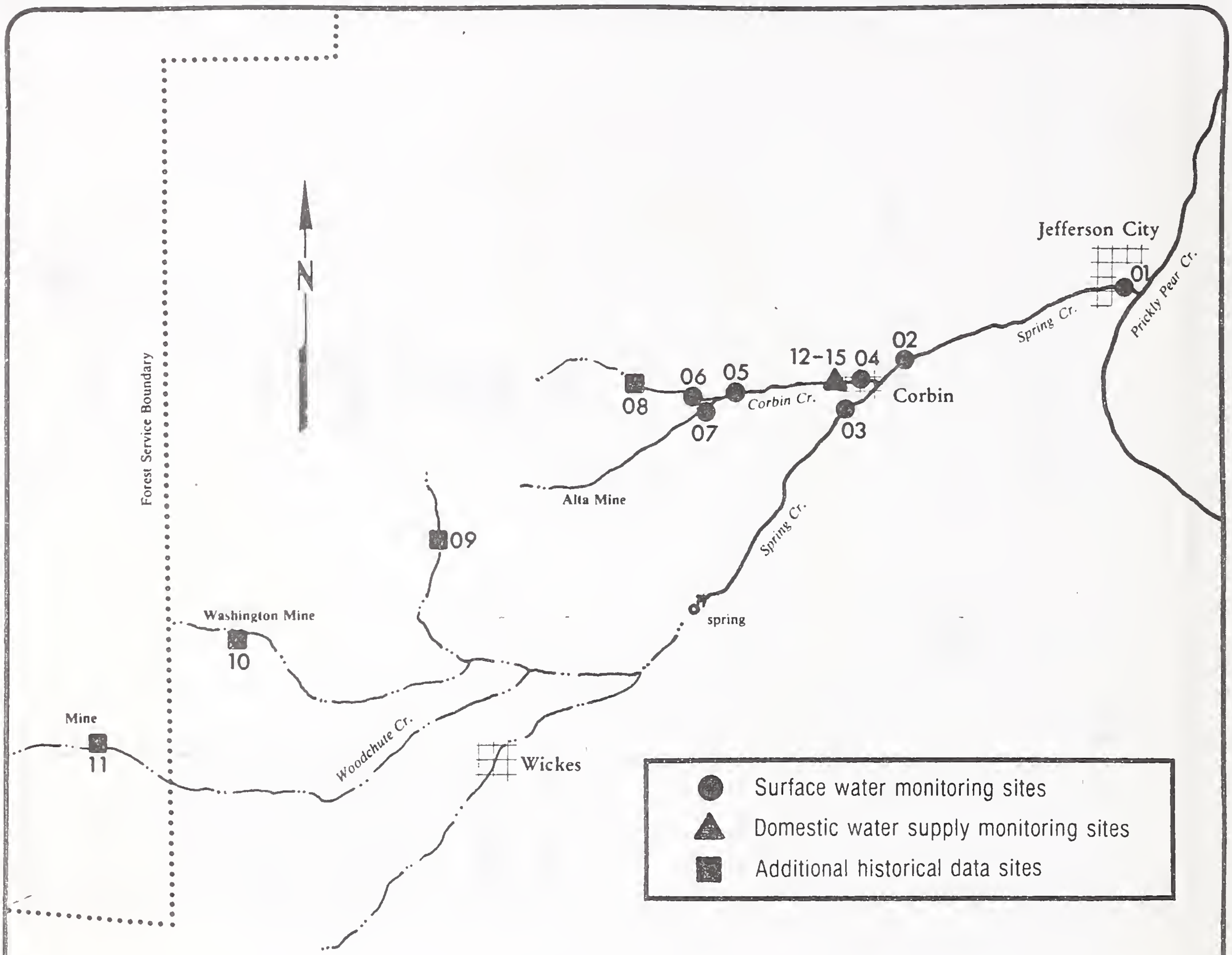
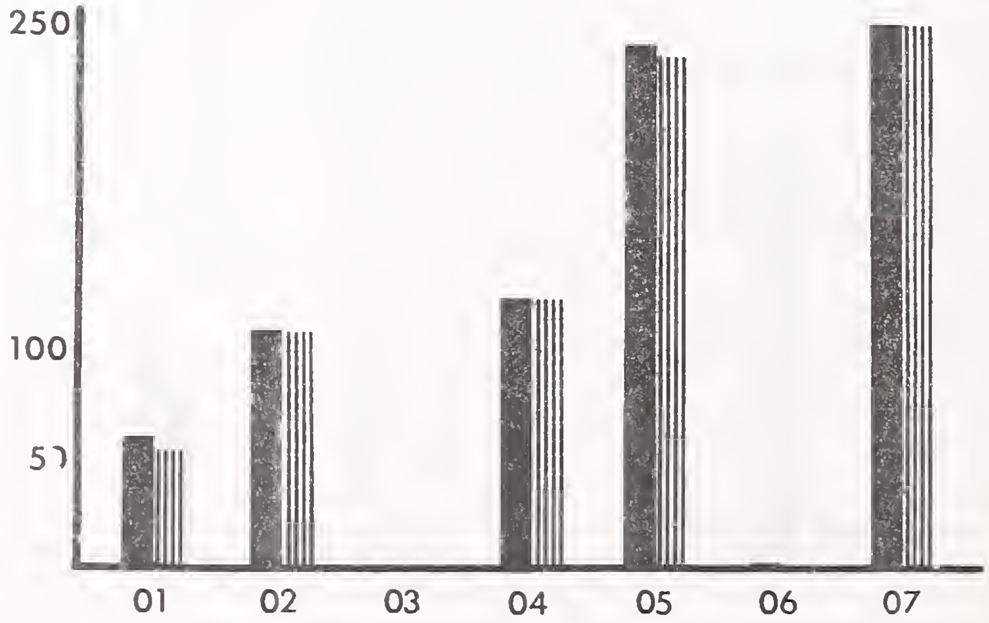


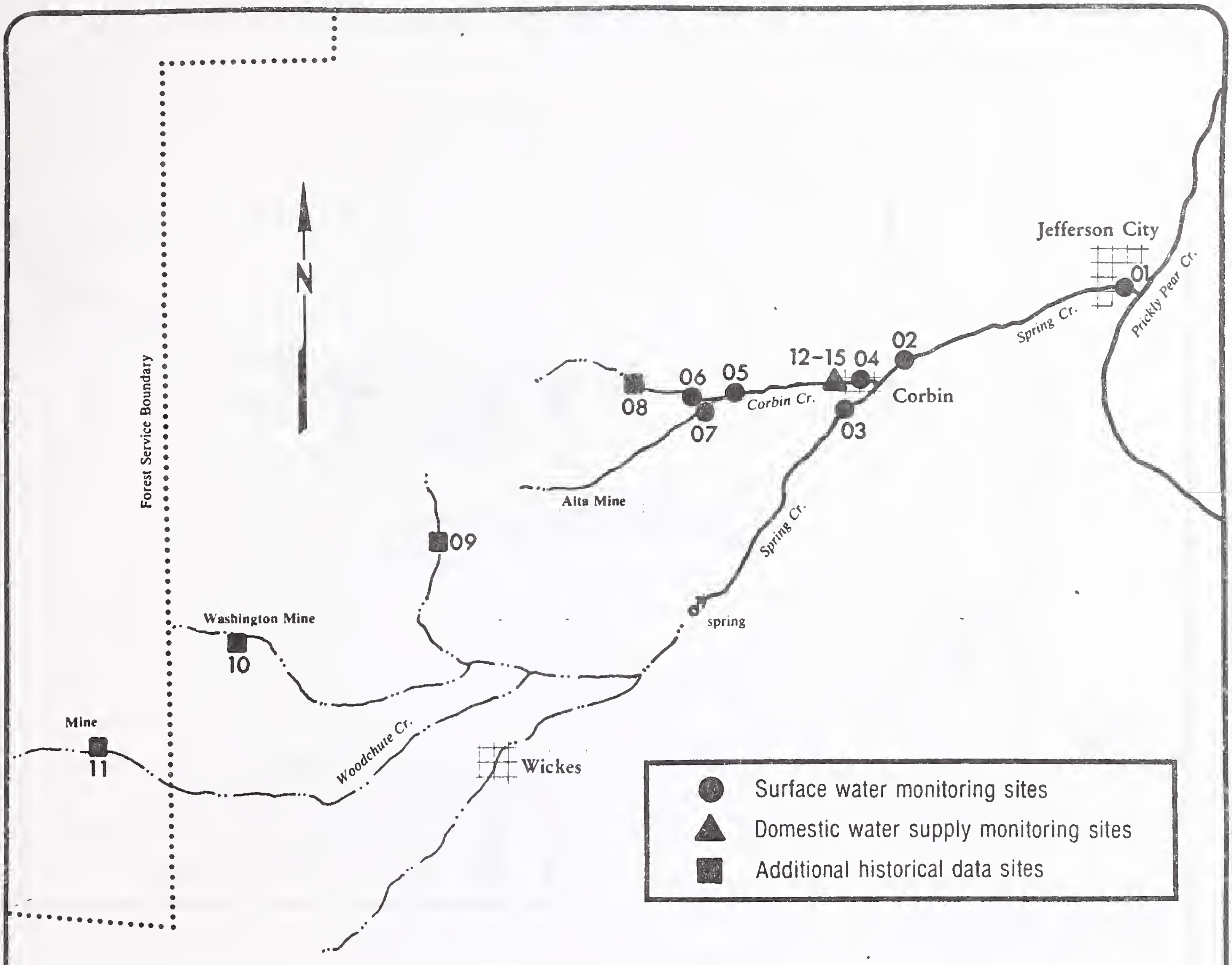
Figure 25

Manganese (load in lb/day)

▨ Total recoverable
||| Dissolved

April 16, 1980





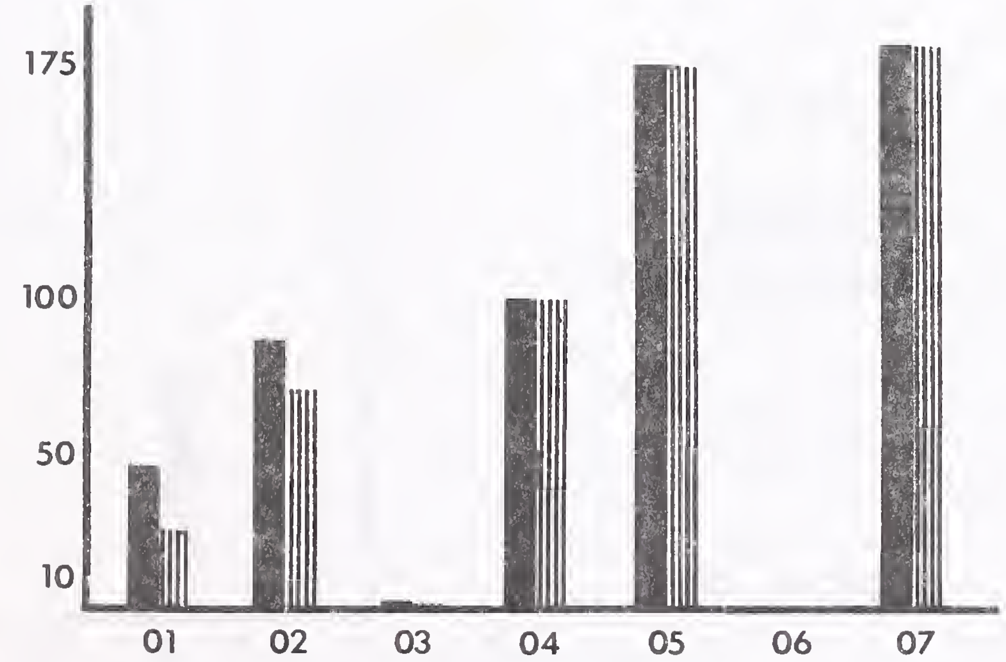


Figure 26

Zinc (load in lb/day)

■ Total recoverable

||| Dissolved

April 16, 1980

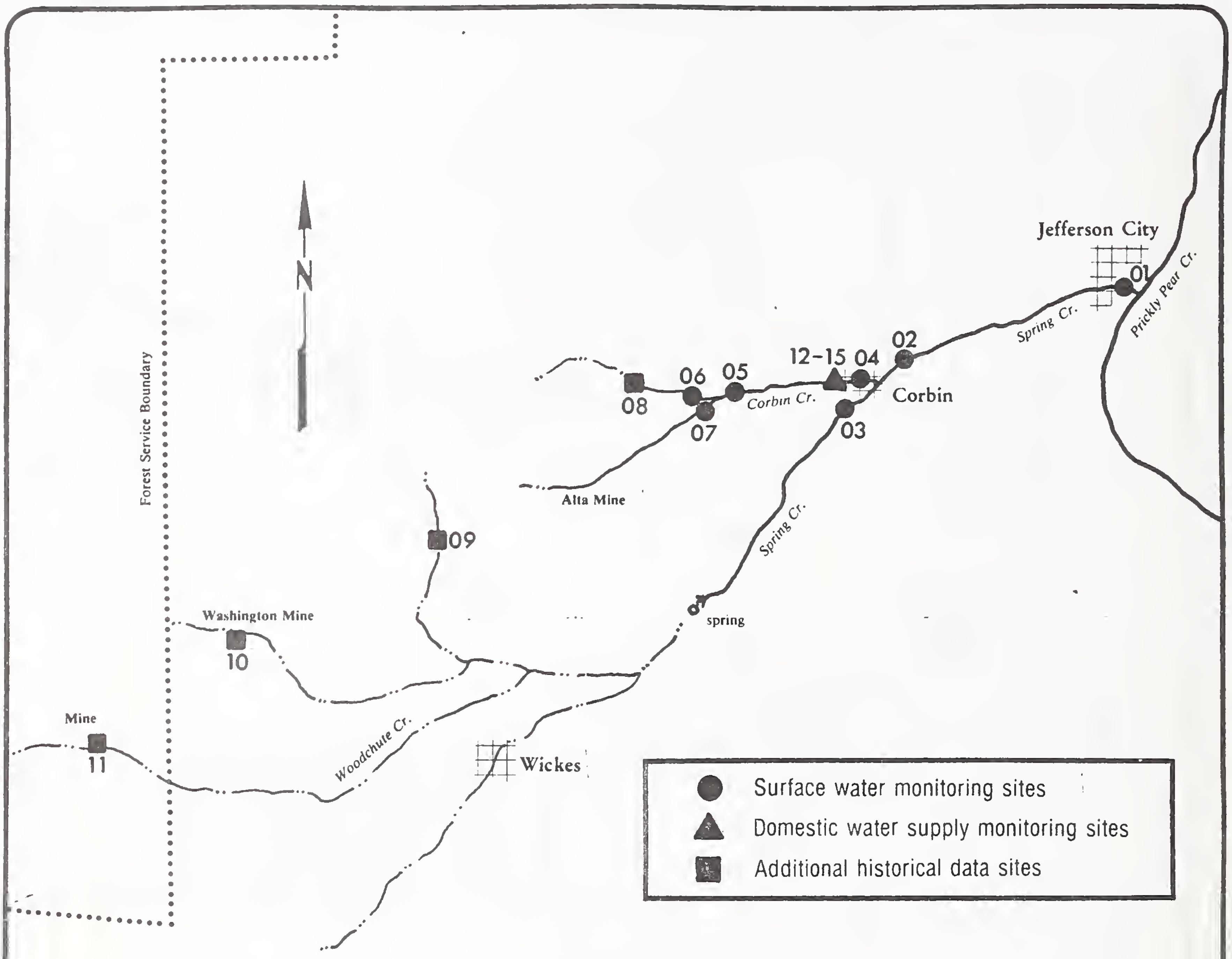
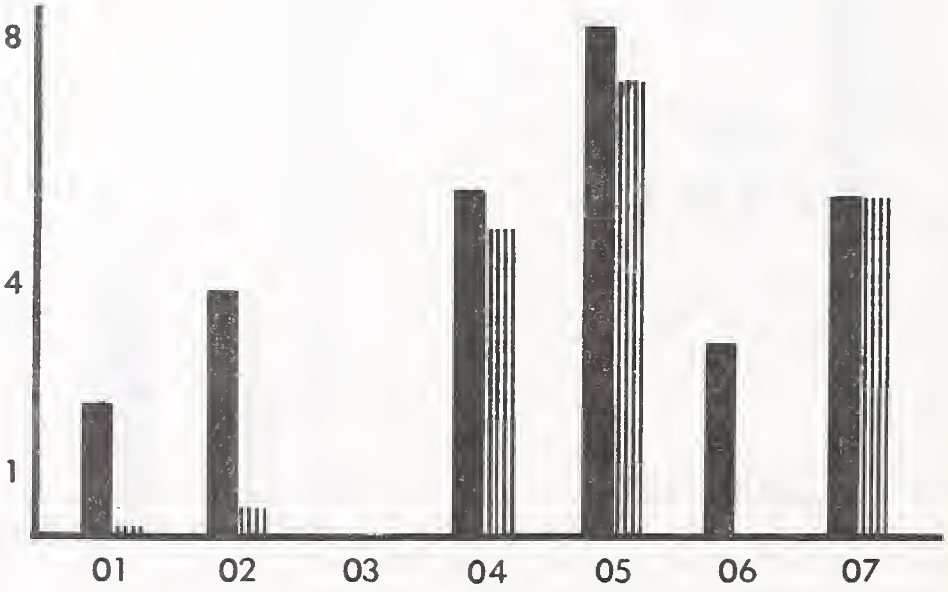


Figure 27

Copper
(load in lb/day)

▨ Total recoverable
|||| Dissolved

April 16, 1980



Conclusions and recommendations

Conclusions

Major conclusions which can be drawn from a review of data for the individual collection sites are:

Surface-water sites

1. At the sites examined in April 1980, frequency of criteria exceeded and pollutant concentrations and loads all generally increased in Spring Creek with increasing proximity to Corbin Creek, and in Corbin Creek with increasing proximity to the Alta Mine discharge.

2. Spring Creek upstream from Corbin Creek contained good to excellent quality water at the times the samples were taken.

3. Corbin Creek upstream from the Alta Mine drainage was the most critical source of sediment in the Spring Creek drainage.

4. The Corbin Flats area was never documented as contributing substantial sediment loads to lower Spring Creek. However, it was shown that this area is capable of adding to the metals load in lower Spring Creek during periods of very high snowmelt runoff.

5. The discharge from the Alta Mine was identified as the most significant source of metals and acid in the Spring Creek drainage.

Historical-data sites

The intermittent drainages in the Wickes area above the origin of Spring Creek received poor-quality mine seeps. Data were very limited. Only on rare occasions do the flows reach Spring Creek. Pollutant concentrations and their effects on Spring Creek at such times have never been documented.

The presence of an apparently healthy and self-sustaining fishery in upper Spring Creek (isolation is imposed by the entrance of Corbin Creek downstream) seems to discount the possibility of intermittent but acutely toxic metals concentrations in this part of the creek.

Domestic water supplies

Of four sites examined, a sump and two fairly deep wells close to Corbin Creek showed evidence of mine-related contamination. The sump contained undiluted Corbin Creek water and was unfit for domestic use. The two wells drew from underground reservoirs and showed high sulfate, hardness and zinc levels. However, the use of this water did not pose threats to human health.

Recommendations

According to the Department of State Lands, the Spring Creek drainage has received approval by the federal Office of Surface Mining as a priority reclamation project under the Abandoned Mine Lands reclamation program. Requests for funding currently are being made.

Based on the findings of this study, the following efforts would result in the most significant improvements in Spring Creek and, in turn, in Prickly Pear Creek water quality:

1. The Alta Mine drainage should be the Number One reclamation priority area. There is little doubt that it is the most critical acid and metal source in the entire Prickly Pear drainage. It is advised that the pollutant source be eliminated by plugging the Alta Mine adit where the flow originates, or by chemical treatment of the discharge to raise and stabilize the pH and precipitate the metals. Removal of the precipitated metals would be necessary.

2. The second priority reclamation area should be the headwaters of Corbin Creek upstream from the entrance of the Alta discharge. This area is the most significant source of sediment and turbidity in Spring Creek. Efforts should be directed toward elimination of the critical sediment sources -- the Bertha Mine tailings, other unvegetated tailings piles, and the unstable soils and streambanks in general. Physical removal of tailings most likely will be required. Additional topsoil and vegetation will have to be brought in to stabilize the resultant scars. A reduction of the sediment load in this area will reduce heavy metals which are bound to the sediment.

3. Due to limited and possibly inaccurate data, a sediment problem has not been proven in the Corbin Flats. However, with its unvegetated, sloughing streambanks, the area is a prime candidate for sediment production during high flows. Metals were shown to increase in Spring Creek as it flowed through the flats under heavy runoff conditions. Therefore, the author feels the area warrants attention as a third reclamation priority. Work should be directed toward stabilizing the streambanks and establishing vegetation. Riprap may be required.

4. Future water-quality monitoring in the Spring Creek drainage should include suspended-solids measurements upstream and downstream from Corbin Flats in conjunction with dissolved and total-recoverable or total-metals sampling.

   The author also recommends monitoring of Spring Creek above Corbin Creek when there is direct overland flow from the intermittent tributaries near Wickes. This would document the severity of pollution in Spring Creek at such times and determine health hazards to Corbin residents who drink from the creek.

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Part IV

“Industrial” impacts on Prickly Pear Creek

Water Quality Bureau
Department of Health and Environmental Sciences

July 1981

Contact person: Rob Greene, 449-2406

Introduction

Sitting close to the Prickly Pear are nine operations which have the potential for impacting the creek. They are:

- Hillbrook Nursing Home at Alhambra
- Mascot Silver and Lead Mine near Clancy
- Kaiser Cement Company at Montana City
- National Cylinder and Gas at East Helena
- Asarco Inc. at East Helena
- American Chemet at East Helena
- East Helena's sewage-treatment system
- Helena Sand and Gravel Company in Helena Valley
- Helena's sewage-treatment system

Of these, five are authorized to discharge wastewater to Prickly Pear Creek under the Montana Pollutant Discharge Elimination System (MPDES). The MPDES program was established in 1968 to regulate the discharge of potentially harmful effluents to Montana's streams and lakes, and is administered by the Water Quality Bureau. Anyone wishing to discharge must have a permit which sets limits on the quality of the effluent to be discharged. Those limits ensure that the effluent's impact on state waters is minimized.

Permit limits vary from discharger to discharger, depending on the existing quality of a particular stream or lake. The Prickly Pear is an interesting case. The upper stretch of the stream -- from just below East Helena up to the headwaters -- is classified in Montana's Water Quality Standards as B-1 and must be maintained at a quality sufficient for drinking and food-preparation purposes (after conventional treatment); for bathing, swimming and recreation; for fish and other aquatic life; for other animal life; and for agricultural and industrial uses. However, the lower Prickly Pear -- from a point beginning at the Wylie Drive crossing below East Helena -- is given an E classification, the lowest classification in the state. An E-classified stream need only be maintained at a quality suitable for agricultural and industrial uses other than food processing. This lower stretch of the creek was classified E by the Water Quality Bureau in 1967 because of annual dewatering.

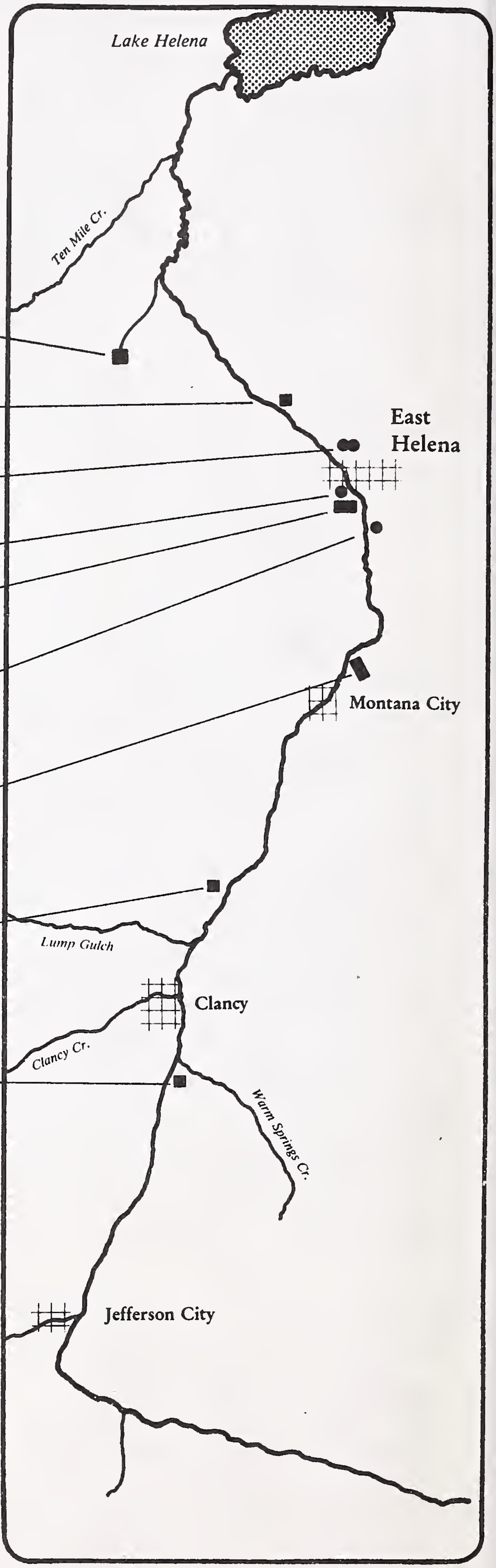
The upshot is: discharge-permit limits are stricter for the dischargers in the upper B-1 stretch than for the lower E stretch. The cities of Helena and East Helena are the only discharge-permit holders in the E stretch. As you will see in Part V of this report (the section that deals in detail with the Helena sewage-plant discharge), the E classification plays a role in perpetuating the low quality of the lower Prickly Pear.

Let's take a look at each "industry" along the Prickly Pear:

Figure 28

"Industries" on Prickly Pear

(with location and MPDES numbers)



Helena sewage-treatment plant
10N 3W 16 CD
MT-0022641

Helena Sand and Gravel
10N 3W 23 AB

East Helena sewage lagoon
10N 3W 24 DC
MT-0022560

American Chemet
10N 3W 36 AB

Asarco smelter
10N 3W 36 AB

National Cylinder and Gas
10N 3W 36 AD
MT-0000426

Kaiser Cement and Gypsum
9N 3W 13 AB
MT-0000451-001
MT-0000451-002

Mascot Mine
9N 3W 34 CA

Hillbrook Nursing Home
8N 3W 16 AB
MT-0023566

Hillbrook Nursing Home

Hillbrook Nursing Home is approximately one mile south of Clancy at the confluence of Warm Springs and Prickly Pear Creeks. An extended-aeration, activated-sludge wastewater treatment plant serves the 120 residents and staff, and treats wastewater from 20 mobile homes in the area. After being processed in the activated-sludge unit and then chlorinated, the wastewater is directed to a "polishing pond" prior to discharge to the Prickly Pear.

The polishing pond also receives water from a hot springs which heats the facility's effluent. The volume of hot water entering the pond varies with the season. Consequently, the effluent from the pond can be made up of from 40 to 80 percent hot-springs water.

This dilution factor, in combination with an effective and well run treatment plant, results in an effluent which has a negligible effect on Prickly Pear Creek.

Mascot Mine

The Mascot Mine (also known as Hab's Mine) is located between Prickly Pear Creek and Interstate 15 about 1½ miles north of Clancy. The mine is a vertical shaft about 25 feet east of the creek. Groundwater in the shaft is pumped to the surface. An investigation by the Water Quality Bureau in 1976 showed that this water was being discharged directly into the Prickly Pear. In response to an order from the bureau, the mine operators constructed a settling/infiltration pond to contain and treat the mine water.

On March 13, 1980, a citizen complained to the bureau about turbid conditions in the creek below the Mascot Mine. An investigation found that the streamside berm of the settling pond had been breached in one corner. This resulted in a small surface discharge to the creek of a greyish, silt-laden solution. Due to the low rate of discharge in relation to the comparatively high flow of the receiving stream, there was no detectable increase of any of the discharge's constituents in the creek. The berm was repaired soon after the inspection.

The Mascot Mine is a potential intermittent source of sediment to the Prickly Pear. Due to the small area available for the operation and the proximity to the creek, adequate construction and placement of treatment ponds is not possible. High spring flows occasionally inundate the area resulting in surface runoff and possibly short-circuiting the treatment system.

As of this writing, the Mascot Mine is shut down. It is not known if or when operations will start again.

Kaiser Cement

The Kaiser Cement and Gypsum Corporation is located near Montana City. Operations at the present site were begun in 1963 (the plant was formerly known as the Permanente Cement Company). Kaiser produces Portland Cement -- 300 tons of it a year, according to a Kaiser official -- and employs 90 workers.

Kaiser is authorized to discharge wastewater to the Prickly Pear at two points under the MPDES program. Discharge 001 consists solely of non-contact cooling water (water that does not come into contact with chemical substances inside the plant). Discharge 002 is groundwater seepage from a percolation/evaporation pond for process-water (water "polluted" inside the plant) and from controlled stormwater runoff. Both discharges are intermittent. Kaiser is required to treat the wastewater discharged at both points to achieve prescribed levels for pH, temperature and suspended solids as defined in its permit.

Kaiser also holds a water right on Prickly Pear Creek to ensure a back-up water supply, but stream water is used infrequently. The main source of water for Kaiser is a deep well on the property.

Kaiser has been the source of two known episodes that resulted in unauthorized discharges to Prickly Pear Creek, both occurring in 1974. The first occurred in January when snow was melting rapidly in an onslaught of unusually-warm weather. High runoff flowed down a normally dry drainage -- which Kaiser used as a waste-material dumping area -- causing the waste material to erode and be carried into the Prickly Pear. The duration of the discharge was about 24 hours. A fish kill occurred in the creek below the Kaiser plant at this time. A dike to contain dumped materials and isolate them from the drainage was constructed immediately to prevent a recurrence.

The second known unauthorized discharge happened when a dike broke on an evaporation/settling basin, releasing a slurry consisting mainly of limestone and silica oxide. About 16,000 gallons of this material flowed into the creek at discharge point 001. The episode lasted only about 10 minutes. No fish kill was reported. To prevent a recurrence, Kaiser has reduced the amount of slurry introduced into the basin and has reinforced the dikes surrounding it.

Unauthorized and uncontrolled discharges from this operation would be a serious threat to the Prickly Pear ecosystem. The highly alkaline nature of the materials handled at Kaiser could raise the pH of natural stream waters and significantly impair the biological community -- a particular concern since Kaiser is located in what is recognized as the most recovered reach of the Prickly Pear.

Kaiser recently obtained a permit to mine an area west of Interstate 15, near Montana City. It's considered a dry site and the open-cut mine should be well contained. The project is not expected to have any impact on surface-water quality, but groundwater may be encountered in the excavation. If so, proper treatment would be required prior to discharge or other means of disposal. The removal of rock from this site was anticipated to begin in 1981.

National Cylinder and Gas

National Cylinder and Gas, a division of Chemetron, is located near East Helena, just southeast of the Asarco smelter. It produces compressed oxygen and nitrogen from the atmosphere.

The plant once drew water from the Prickly Pear and supplemented it with water from an onsite well. Recently, however, the plant has switched to using well water only. Chemetron is authorized to discharge non-contact cooling water to Prickly Pear Creek under an MPDES permit.

The effluent limitations imposed upon Chemetron's permit allow a maximum discharge of 1.5 million gallons per day with a temperature not exceeding the creek's instream temperature by more than 4 degrees F. The discharge enters the creek just upstream from Asarco's dam. The warming of the Prickly Pear by the impoundment tends to mask the effects of Chemetron's thermal loading.

Asarco Inc.

Asarco, formerly known as American Smelting and Refining Company, operates at East Helena a smelter which processes domestic and foreign ores. The primary products are lead bullion and zinc oxide. By-products include sulfuric acid, matte (iron, copper and lead oxides) and speiss (copper arsenides and antimonides) which are sent to other plants for further refining. Asarco employs about 360 people at its East Helena operation.

Prior to the 1970s, little consideration was given to the impact of the smelter on the Prickly Pear ecosystem. Non-contact cooling water was discharged continuously at a rate of 2.1 million gallons per day. Effluent from the washing of the speiss was released into the creek along with the effluent from several other process lines. These discharges caused elevated stream temperatures and heavy-metal concentrations in the creek. During the summer months when water in the creek was naturally warmer and lower than usual, the dose of metals and heat from Asarco were considered to be the cause of several reported fish kills.

In November 1972, the intermittent discharge of the speiss water was eliminated by the installation of closed-circuit equipment that recirculated the former effluent. The following year, a water-cooling tower was put on line to reduce the temperature of the non-contact cooling water prior to discharge. By September 1975, the cooling-water discharge was eliminated by the adoption of a recirculation system and surge basin. In October 1975, Asarco eliminated a thermal discharge from the recirculation pond and further isolated the pond from Prickly Pear Creek and surface runoff. These actions made Asarco a non-discharging facility and its MPDES permit (#0000345) was not renewed upon its expiration.

Since the time the Asarco smelter went to a closed-circuit system, two short-term, unauthorized discharges have been observed. These have been attributed to mechanical failures in the recycle system.

One occurred in October 1979 when a pump failure at the surge basin caused a system overload. This allowed metal-laden cooling water to flow down the old discharge pipe into the Prickly Pear. This situation was corrected by the installation of higher capacity pumps and alarm system and sealing off the old discharge culvert.

The other occurred in October 1980 when a "pond-inflow only" gate between the creek and the pond failed, allowing cooling water to drain back from the pond into the creek. This discharge was eliminated when the pipe on which the gate was installed was sealed with concrete.

The Wilson Ditch

The Asarco smelter is the point of diversion for a small irrigation canal known as the Wilson Ditch. Water is withdrawn at a headgate on Asarco's upper lake, enters an underground culvert and surfaces in an open ditch at Asarco's western property line. At this point, the flow is regulated by a parshall flume before proceeding in a northwesterly direction into Helena Valley. Excess water enters an overflow ditch which once returned to the creek just downstream from the smelter. Wilson Ditch provides irrigation water to ranchers Cliff Lamping and Don Burnham. In the spring of 1980, Asarco completed the burial of the ditch through its property, replaced the headgate and blocked the overflow from entering the Prickly Pear.

Over the years, water sampling has revealed elevated metal concentrations in the Wilson Ditch and the overflow. In the spring of 1980, Asarco conducted a video inspection of the buried portion and discovered several process lines discharging to the ditch. Another discharging line was found later in 1980. All of those discharges were soon eliminated, and heavy-metal concentrations have been cut.

Wilson Ditch also was being contaminated by surface runoff from the Holmes Gulch area south of the smelter. That extremely turbid runoff flowed down the ditch, into the overflow, then into the Prickly Pear. This source of sediment was eliminated in July 1980 when Asarco rerouted the drainage out of Holmes Gulch and directed it into their upper lake.

The smelter dam

Asarco operates a small impoundment on the Prickly Pear mainstem, backed up by what's commonly called "the smelter dam." The smelter dam has a limited storage capacity and originally provided water for various processes. Since the conversion to a closed-circuit system, the only use for the impoundment was to provide cooling water for National Cylinder and Gas and water to a irrigation ditch owned by Bob Garber. National Cylinder and Gas now draws all its water from wells and no longer needs the impoundment.

The impoundment acted as a sediment trap, settling out larger suspended particles by reducing the creek's flow. Most of this material is a decomposed granite, a coarse sand-like material typical of the geology in the Prickly Pear drainage. In August 1979, while conducting routine biological monitoring, Water Quality Bureau personnel discovered that an earlier flushing of the accumulated sediments from the impoundment had blanketed the streambottom downstream from the dam for several miles. The bottom-dwelling organisms were destroyed or displaced. And the released sediments caused problems in downstream irrigation systems. It was several months until streamflows carried the sediment away and the original streambed was exposed.

This episode prompted an agreement between the state and Asarco that flushing of the impoundment could occur only during the spring runoff period. The increased streamflows and consequential increased carrying capacities during this time were felt to mitigate the effects of the flushing on the creek's aquatic community.

The impoundment also tends to increase temperatures in the creek and the dam was a barrier to fish passage, precluding upstream spawning runs.

The flood of May 1981 cut a new channel around the smelter dam, causing Asarco to lose its impoundment. The company immediately petitioned the Lewis and Clark County Conservation District for a permit to rebuild the structure, mainly because the dam was the route of an important service road across the creek. The Water Quality Bureau and the Department of Fish, Wildlife and Parks, however, objected. They felt the impoundment was no longer necessary and saw this as a good opportunity to rid the creek of two long-standing problems -- the sediment trap and the fish barrier.

At first, Asarco agreed that a bridge might replace the dam. But their minds were changed by a hydrologist from their parent company who felt the impoundment was necessary to preserve the static level of the upper lake, from which the plant water and the Wilson Ditch water is withdrawn. State agencies vehemently disagreed, feeling that a berm built on one side of the upper lake would hold the water while leaving a free-flowing Prickly Pear. In July 1981, the state and Asarco compromised. Asarco was allowed to rebuild its dam, but agreed to leave two existing gates open a few inches at the bottom year-round to allow sediment to move through and to open the gates completely twice a year--during brown and rainbow trout spawning runs--allowing a free-flowing stream for the fish passage.

Another source of metal pollution was discovered downstream from the smelter dam. Just upstream from the Highway 12 bridge, between Asarco's slag pile and the creek, is a low swampy area. Occasionally, surface pooling occurs, and this water creates a small discharge to the creek. Analyses have shown extremely elevated metals concentrations and moderately elevated temperatures in this water. Some of the water and metals were eliminated when Asarco reduced its slag pile sprinkling, initiated as a dust-control measure. The area still seeps into the Prickly Pear during times of high groundwater, but metal concentrations are decreasing as the area is flushed out. Both Asarco and the Water Quality Bureau are continuing to study the problem.

The debilitating effect of the Asarco smelter on the Prickly Pear ecosystem has been greatly reduced in the last 10 years. The relationship between the two has evolved from viewing the stream as a means of carrying away wastes to one of considering the stream for its many beneficial uses, including the potential for recreation.

American Chemet

American Chemet is located on the north side of the Asarco smelter property. This plant uses a heating process to manufacture approximately 400 tons per month of zinc and copper oxides which are then used elsewhere in the making of rubber and paint. The process is considered a "dry" one in which no water is used -- making American Chemet a non-discharging facility. American Chemet employs about 45 persons.

The plant officials are considering adopting a "wet" process for the production of copper oxides. Water would be obtained from an on-site well and then recycled, ensuring American Chemet's non-discharge status. The new "wet-process" facility would be located just south of the present operation.

American Chemet is unique in that most of the raw materials it uses are former waste products -- for example, the zinc fumes from Asarco are turned into a usable product. Such a maximum utilization of a product is applaudable, and is reflected too in their planned use of a recycling system for their water.

East Helena lagoon

East Helena's sewage-treatment lagoon consists of two seven-acre ponds. They are authorized to discharge into the Prickly Pear under an MPDES permit (#MT-0022560). The effluent enters the creek just downstream from the Wylie Drive crossing, except during irrigation season when most of the ponds' outflow is directed into irrigation ditches.

The lagoon serves about 1800 East Helenans, which is 400 more than it is designed for. It also receives wastes from two industries, Asarco and American Chemet. Because the lagoon is operating over its capacity, East Helena has entered the design phase for constructing three new aeration basins to provide secondary treatment for the city's wastewater. The existing lagoon will be abandoned. It is anticipated that the secondary treatment facilities will be completed in July 1982. This will significantly improve the quality of the effluent and lessen the discharge's impact on the Prickly Pear ecosystem.

Helena Sand and Gravel

Helena Sand and Gravel is located about three miles downstream from East Helena. The operation crushes and washes gravel and processes sand. There is no surface discharge authorized.

Washwaster is directed to one of several large settling/infiltration ponds. Occasionally, these ponds require dewatering because they've filled with groundwater and surface runoff. This occurred in 1978 and permission was given for them to discharge to the Prickly Pear since the accumulated pond water was found to be of equal or higher quality than the creek water.

One unauthorized discharge from Helena Sand and Gravel occurred in the fall of 1975 when washwater was diverted from its normal route to the ponds and into the Prickly Pear. This created an extremely turbid condition in the creek downstream from the discharge and spurred an enforcement action against the company. Since then, Helena Sand and Gravel has had no unauthorized discharges.

Helena sewage-treatment plant

See the next section of this report, which deals entirely with this plant.

And in summary...

Of all these "industrial" impacts on the Prickly Pear, only the Helena sewage-treatment plant discharge has a significant, continuing effect on the water quality of the creek. That's why we are describing these effects in detail in the following section. Except in the sewage plant's case, the Water Quality Bureau and the Montana Pollutant Discharge Elimination System are controlling the impacts on the creek from dischargers. But with the sewage plant, the Bureau, through MPDES, is powerless to minimize the impacts because of the creek's classification -- as we shall explain. . .

Part V

Helena's sewage plant: its effects on Prickly Pear Creek

Water Quality Bureau
Department of Health and Environmental Sciences

July 1981

Contact person: Gary Ingman, 449-2406

Introduction

Sewage-treatment plant (STP) discharges contain a complex mixture of substances -- organic and inorganic, simple and complex compounds. The organic materials include carbohydrates, proteins and fats as well as products of their decomposition. The inorganic compounds include salts, nitrates, nitrites, phosphates and ammonia. Some of the sewage constituents are dissolved, some colloidal and others suspended but capable of settling.

Surface waters will be affected by all the components of sewage, while the streambed will be altered primarily by the settling solids. The extent of impacts created by an STP discharge on the receiving waterway is, in part, a function of effluent quality and the availability of dilution water. The poorer the quality of a particular discharge and the smaller the receiving waterway, the greater will be the water-quality degradation and the downstream distance before improvement.

Sewage discharges can create health hazards, reduce recreation and aesthetics, and impair or eliminate desirable stream life. The main health hazard is the presence of disease-causing organisms. Surface waters receiving domestic sewage frequently contain great numbers of bacteria from the feces of man and other animals. Although most of these bacteria are not harmful to humans, the possibility exists that pathogenic (disease-causing) bacteria and viruses are present. Chlorination and other methods of disinfection, although routinely practiced on sewage effluents prior to discharge, generally do not eliminate all the organisms. Excessive chlorination should be avoided because of its toxic effect on desirable stream life. The dangers associated with pathogens lie not only in consumption of the water; there is also the potential for human infection through body contact -- swimming.

Other pollutants posing health hazards in streams receiving sewage include pesticides and heavy metals.

Recreational and aesthetic values may be impaired in waterways receiving sewage if threats to health exist or if the discharge contains: (1) materials that will settle to form objectionable deposits; (2) floating debris, oil, scum or other matter; (3) objectionable color, odor, taste or turbidity; or (4) substances and/or conditions that produce undesirable aquatic life, such as nuisance algae, insect pests, etc.

A description of the ecological derangement resulting in the community of stream-dwelling organisms below sewage discharges is beyond the scope of this report. However, the mechanism by which the impacts are induced is commonly one or more of the following seven types:

- First, the waste discharge may cause an oxygen depletion in the receiving stream, either by increasing bacterial activity and metabolism or by producing a chemical oxygen demand.

- Second, the waste may be directly toxic to stream life, either due to the nature of the waste or through induced changes in pH and other stream conditions.

- Third, sewage discharges frequently are warmer than receiving streams and the sudden increase in temperature below the discharge may harm some forms of aquatic life.

- Fourth, the physical nature of the wastes may be harmful as well. Suspended solids may be abrasive or oil may be present, both of which are capable of damaging gill structures.

- Fifth, wastes may alter the nature of the habitat by causing turbidity or by smothering natural living areas with silt.

- Sixth, the chronic effects of sewage may predispose aquatic organisms to mortality from natural factors.

- And last, the presence of algal-growth stimulants like nitrates and phosphates, while not necessarily toxic to aquatic life, may produce a fertilizing effect capable of upsetting the delicate balance within the aquatic food chain.

These types of impairment are often interrelated. For example, algal nutrients originating in an STP discharge may promote the propagation of a toxin-producing blue-green algae in a downstream lake. Thus, an effect on aquatic life -- in this case, algae -- might result in threats to human health and cause impairment of recreation and aesthetics.

Characteristics of the Helena sewage-treatment plant discharge

Before 1975, Helena's sewage-treatment plant only provided primary sewage treatment, consisting of solids removal and little more. Grit separators physically removed coarse particulates such as sand. Afterwards, a comminutor and bar screen shredded and collected rags and the like. Then a primary clarifier settled out and removed sludge and other suspended solids from the remaining liquid. Finally, the waste was chlorinated and discharged, by way of a mile-long ditch, to Prickly Pear Creek.

Investigations showed that the Prickly Pear was severely polluted by the poorly treated, oxygen-demanding wastes. It was easy to smell the foul odors, see the beds of sludge and capture large populations of pollution-tolerant organisms.

Secondary treatment facilities were built at the Helena STP in 1975. The previous treatment was supplemented with an activated bio-filter (ABF) and two secondary clarifiers. The ABF structure provides a growth medium for bacteria which decompose the organic wastes in the sewage, thus reducing the oxygen demand of the wastes which is capable of reducing the dissolved-oxygen content of the receiving stream. The secondary clarifiers further remove settleable solids which, apparently, the single primary clarifier was not capable of doing consistently.

Most of the time now, the effluent discharged from Helena's sewage treatment facilities meets permit limitations of the Montana Pollutant Discharge Elimination System (MPDES), administered by the Water Quality Bureau (see Part IV of this report). Occasional exceedences do occur, usually a result of plant malfunctions. The discharge permit (MT-0022641) restricts quantities of total suspended solids, fecal coliform bacteria and residual chlorine in the effluent, as well as pH levels and oxygen demand.

As discussed in the Introduction to Part IV of this report, the Prickly Pear Creek in the area that receives the Helena STP discharge has been classified E, the lowest possible classification, due to a chronic dewatering problem. This low classification allows the Water Quality Bureau to set looser restrictions on the effluent than would be allowed on the upper Prickly Pear, which is classified B-1.

Study design

Prickly Pear Creek in the vicinity of the Helena sewage-plant discharge has been the site of water-quality investigations at least since 1973. Sampling after 1975, when secondary treatment facilities began operating at the plant, shows an improvement in effluent quality but continued degradation of the Prickly Pear. Most of this monitoring was performed at the county bridge near Mountain View School, some two stream miles below the discharge, because of ease of access.

Considering the possibility that water quality might be significantly poorer immediately below the discharge, a monitoring program was established there in December 1979. Sites were established immediately upstream from the discharge, at the mouth of the discharge, and a sufficient distance downstream from the discharge to ensure complete mixing of the waste with the creek water. Results of monitoring at the Mountain View site were used to supplement the data base and show downstream changes in water quality. The four sites are pinpointed in Table 29 and Figure 29.

Parameters

Seven parameters, plus streamflow, were selected for coverage in this section of the report. Four of these parameters -- turbidity, total soluble inorganic nitrogen, total phosphorus and fecal coliform bacteria -- address matters of public health, recreation and aesthetics. The remaining three parameters -- ammonia, suspended solids and dissolved oxygen -- affect aquatic life. Rationale and criteria for these parameters, except dissolved oxygen and fecal coliform bacteria, have been explained in the overview section (Part I) of this report.

Dissolved-oxygen measurements taken on a stream above and below a municipal wastewater discharge will indicate the level of oxygen depression in the stream resulting from the oxygen demand of the

Figure 29

Sampling-site locations

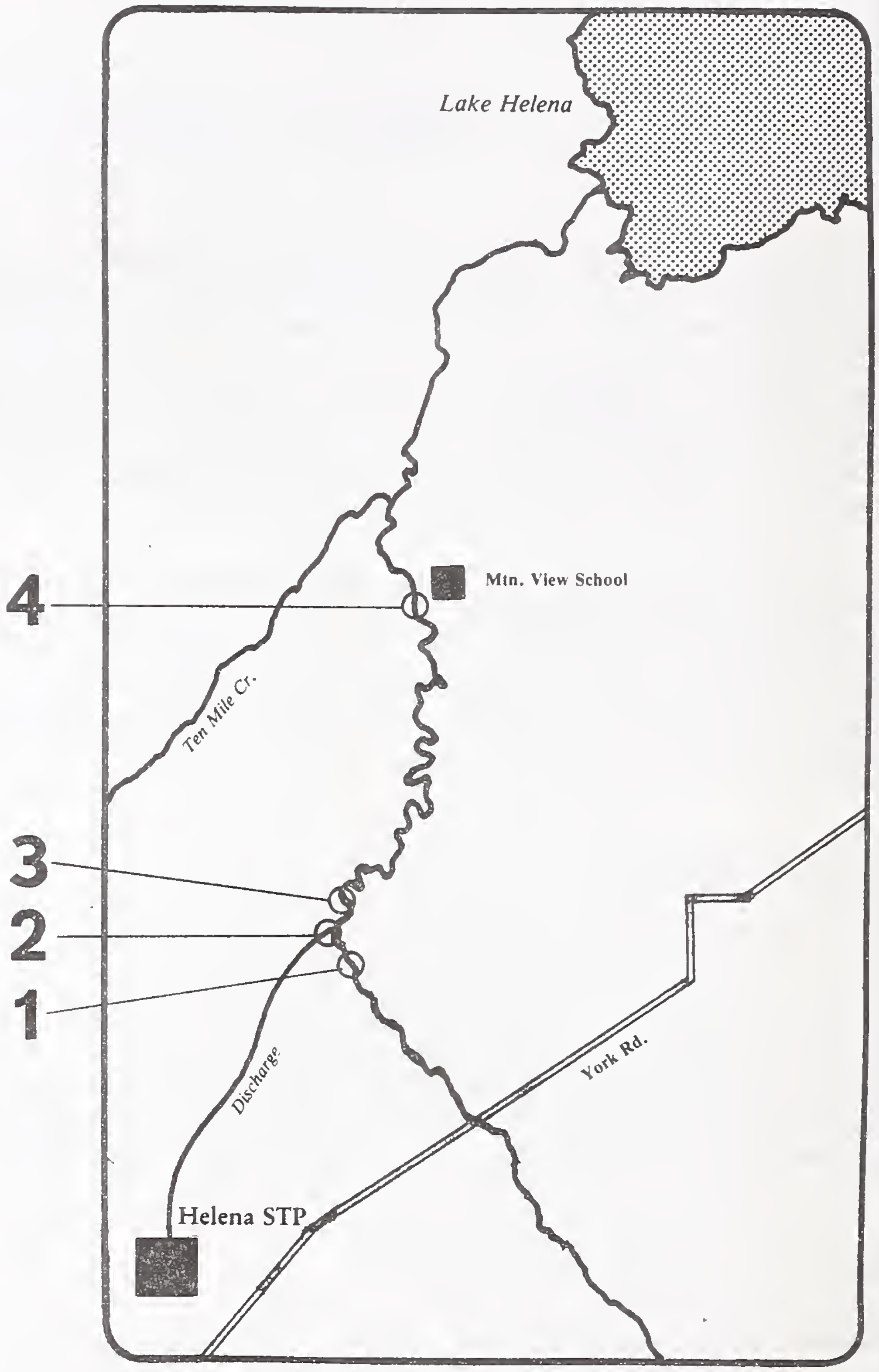


TABLE 29

Monitoring stations in vicinity of Helena sewage-plant discharge

No.	Location	Township	Range	Section
01	Prickly Pear Cr. immediately above Helena STP* discharge	10N	3W	9ACD
02	Helena STP effluent at point of discharge to Prickly Pear Cr.	10N	3W	9ACD
03	Prickly Pear Cr. 0.3 mile below STP discharge	10N	3W	9ACD
04	Prickly Pear Cr. at Mountain View School (2 miles below discharge)	10N	3W	3BBA

*Sewage-treatment plant

decomposing wastes in the discharge. Oxygen requirements of aquatic organisms are highly variable. However, levels adequate for fish propagation are generally sufficient for the rest of the aquatic community. Cold-water fish, specifically trout and salmon, have higher dissolved-oxygen requirements than warm-water varieties and a concentration of 7 milligrams per liter (mg/l) has been established as the minimum safe oxygen level for successful cold-water fish spawning. For good growth and the general well-being of trout, salmon and associated organisms, the level should not fall below 6 mg/l (FWPCA, 1968).

Fecal coliform bacteria are used to indicate fecal pollution and potential exposure to pathogens, even though only a small percentage of the coliform group may be pathogenic. It's more difficult to isolate and identify each of the pathogenic species. Surface waters routinely contain some "background" fecal coliform bacteria from animal feces. Excessively high concentrations, however, are not common and they point to pollution. Although no detectable quantities of bacteria in the coliform group are allowable in municipal drinking water after treatment, waters used for body-contact recreation are considered safe if the fecal coliform content does not exceed a mean -- based on at least five samples -- of 200 organisms per 100 milliliters. Additionally, no more than 10 percent of the total samples taken during a 30-day period should exceed 400 organisms per 100 milliliters (Thurston et al, 1979).

Parameters used in this section and applicable criteria are listed in Table 30.

Methods

Water-quality sampling performed at the three stations near the STP discharge consisted of intensive one-day efforts in December 1979 and September 1980. The December period was chosen because it is a time of low streamflow in the Prickly Pear. Since dilution is less than at other times of the year, pollutants will be more concentrated. Also, cold temperatures in the winter months may result in a low efficiency of the Helena wastewater treatment plant's ABF structure because of decreased activity of the bacteria that decompose the wastes. Therefore, pollutants -- especially ammonia -- are likely to be present in greater concentrations in the effluent during winter.

The quantity of un-ionized ammonia present in solution -- and hence the potential for toxicity -- is directly proportional to temperature and pH. The September sampling period was chosen to document effects of the STP discharge during conditions of high stream temperature and pH.

In December, samples were taken at the three sites every three or four hours, from 8:30 a.m. to 7:30 p.m. In September, the sites were sampled every two hours from 7:00 a.m. until 7:00 p.m. The repetitive samplings determined the daily variation in quality and quantity of the effluent and the resultant range of impacts on Prickly Pear Creek during these time periods.

TABLE 30 List of parameters and applicable criteria

Parameter	Criteria*: Public health, recreation and aesthetics	Criteria*: Protection of freshwater aquatic life
Streamflow (cfs)	--	--
Total phosphorus (mg/l)	.05	--
Total soluble inorganic nitrogen (NO_2+NO_3-N plus NH_3-N in mg/l)	.35	--
Fecal coliform bacteria (number per 100 ml)	200	--
Turbidity (NTU)	5	--
Total suspended solids (mg/l)	--	25 and 80**
Un-ionized ammonia (NH_3-N in mg/l)	--	.016
Dissolved oxygen (mg/l)	--	7

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*Criteria for parameters other than dissolved oxygen and fecal coliform bacteria are summarized in the water quality overview section of this report. The 7 mg/l dissolved-oxygen criterion is the minimum level required for successful spawning of cold-water fishes (FWPCA, 1968). The fecal coliform criterion is the maximum recommended level for body-contact recreation water (200 organisms per 100 ml based on a log mean of a minimum of five samples taken over a 30-day period. Thurston et al, 1979).

**Fisheries can be maintained in waters containing 25 to 80 mg/l suspended solids, but the yield of fish might be lower than in waters containing 25 mg/l or less. Waters carrying more than 80 mg/l suspended solids are unlikely to support good freshwater fisheries (FWPCA, 1968).

The two intensive monitoring runs were supplemented with one-time samplings in late December 1979, January and November 1980, and January 1981. Additional data for the period of May 1977 to December 1979 were used where available.

The Mountain View site was sampled according to the scheme explained in the overview section (Part I) of this series. Ten additional sets of data for the period June 1977 to March 1978 and one each for November 1980 and January 1981 which were on hand were included to bolster the data base.

The collection, handling and analysis of samples for the seven parameters generally followed "Standard Methods" (APHA et al, 1975) or equivalent EPA-sanctioned procedures (USEPA, 1976; USEPA, 1979). Streamflows were measured by methods approved by the U.S. Geological Survey.

The results of this investigation will be evaluated by site. For each site, data for the seven parameters will be presented in a tabular fashion. Included will be the number of individual measurements performed, the minimum, maximum and mean observed values for each parameter and the number of criteria "exceedences" recorded. Obviously, the criteria used in this section will not be particularly applicable to the STP discharge itself because it is not likely to be used for drinking or recreation or considered an important source of habitat for desirable stream life. However, the number of recorded exceedences will characterize the quality of the effluent and denote which pollutants are likely to be the most critical problems. Preceding the data table for each site will be a written assessment of conditions.

Although individual data for the intensive one-day samplings in December 1979 and September 1980 are not included in the tables, observed trends will be addressed in the written interpretation. Individual data are on file at the Water Quality Bureau.

Results and interpretations

Site 01

Upstream from Helena STP discharge

Data for this site show a mean streamflow of nearly 36 cubic feet per second (cfs) based on 17 measurements. These figures do not reflect the chronic dewatering known to occur in this area during mid-summer, because data are lacking for that period. In August 1980, streamflow at the York Road -- just upstream from this site -- was observed to be about 1 to 2 cfs. Most of that flow was contributed by groundwater recharge or irrigation return flows. Prickly Pear Creek was entirely dry a short distance upstream from York Road.

Above the entrance of the Helena STP effluent, the Prickly Pear was found to be in a state of considerable nutrient enrichment. Mean total phosphorus concentrations exceeded maximum recommended instream levels by nearly twice and the highest observed concentration exceeded the criterion by more than 10 times. Mean total soluble inorganic nitrogen levels exceeded the criterion by 1.3 times, whereas the maximum recorded levels exceeded it by more than 3 times. Given these excess nutrient concentrations, this reach of the stream would be capable of supporting nuisance growths of aquatic plants. However, the lower Prickly Pear is a relatively low-gradient stream and sediment originating from upstream (see streambank inventory section, Part II of this report) precipitates to the streambottom throughout this reach and results in a very unstable, shifting, sandy bottom. Growth of algae and other aquatic plants are limited by this lack of a suitable streambottom.

Although nutrient sources have not been identified specifically, significant increases in nitrogen and phosphorus levels are routinely observed between East Helena and this site. Since the data show relatively constant nutrient concentrations, contributions from livestock and the East Helena sewage lagoon discharge seem to be the most likely sources.

Turbidity, total suspended solids and fecal coliform bacteria were rarely a significant problem at Site 01. Dissolved oxygen was plentiful on the occasions it was measured and concentrations of un-ionized ammonia were never detectable.

TABLE 31

Site No: 01 Immediately upstream from Helena STP discharge

					Number of exceedences	
Parameter	Sample size	Minimum value	Mean	Maximum value	Public health, recreation and aesthetics	Protection of freshwater aquatic life
Streamflow (cfs)	17	13.1	35.7	57.9	--	--
Total phosphorus (mg/l)	17	.026	.094	.510	13	--
Total soluble inorganic nitrogen (mg/l)	17	.12	.46	1.11	12	--
Fecal coliform bacteria (orgs. per 100 ml)	6	<4	126	520	1	--
Turbidity (NTU)	6	3.8	5.6	7.5	0	--
Total suspended solids (mg/l)	8	9.6	18.0	31.8	--	at 25 2 at 80 0
Un-ionized ammonia (mg/l)	14	<.001	<.001	<.001	--	0
Dissolved oxygen (mg/l)	4	11.79	12.42	12.70	--	0

Site 02

Helena sewage-treatment plant discharge

Based on the available data, the STP effluent contributed an average 12.5 percent of the flow in Prickly Pear Creek below the discharge, although contributions as high as 30 percent were recorded. That 30 percent figure is most certainly exceeded during peak irrigation withdrawals on the creek, such as in August 1980. It is likely that the STP effluent's flow on such occasions exceeds the streamflow in Prickly Pear Creek. On a daily basis, the flow coming out of the treatment plant varied by as much as 270 percent.

All of the criteria for the seven water-quality parameters used were routinely exceeded in the effluent. Phosphorus and nitrogen, on the average, exceeded recommended levels by approximately 142 times and 44 times, respectively. Maximum recorded levels exceeded the criteria by up to 520 times for the phosphorus and 54 times for nitrogen. Total suspended solids and fecal coliform bacteria usually exceeded the applicable criteria and, in fact, exceeded the Helena STP's discharge permit limitations on several occasions. Dissolved oxygen levels in the effluent would have prevented salmonid spawning.

Un-ionized ammonia concentrations averaged 7 times greater than the maximum level established to protect freshwater aquatic life. A review of the individual ammonia measurements revealed some important facts: the levels of un-ionized ammonia in the effluent were quite variable on a seasonal basis; the highest recorded levels were measured in the winter; and, as suspected, the STP's ABF structure apparently does not function efficiently in cold temperatures -- as a result, less ammonia in the sewage is oxidized to a less harmful nitrate, its degradation product.

Daily fluctuations in effluent ammonia concentrations were not significant. However, concentrations of the other pollutants were shown to be quite variable during the day, apparently due to variations in the quality of raw sewage coming into the treatment plant.

TABLE 32

Site No: 02 Helena sewage-treatment plant discharge

					Number of exceedences	
Parameter	Sample size	Minimum value	Mean	Maximum value	Public health, recreation and aesthetics	Protection of freshwater aquatic life
Streamflow (cfs)	16	< 1	5.1	7.2	--	--
Total phosphorus (mg/l)	15	3.5	7.1	26	15	--
Total soluble inorganic nitrogen (mg/l)	16	8.4	15.32	19.05	16	--
Fecal coliform bacteria (orgs. per 100 ml)	6	30	3538	19,000	3	--
Turbidity (NTU)	6	6.8	9.9	20.2	6	--
Total suspended solids (mg/l)	8	23.4	41.6	64.2	--	at 25 7 at 80 0
Un-ionized ammonia (mg/l)	8	.047	.114	.196	--	8
Dissolved oxygen (mg/l)	5	4.89	5.49	5.98	--	5

Effects of sewage-treatment plant

Site 03

Downstream from Helena STP discharge

Despite the appreciable streamflows in Prickly Pear Creek downstream from the STP discharge at the times of sampling, water quality was found to be significantly degraded. Nitrogen and phosphorus in the STP effluent clearly aggravated the enrichment problem detected in the creek at Site 01. Mean total phosphorus levels exceeded recommended limits by nearly 27 times and some measurements surpassed the limits by as much as 90 times. Nitrogen exceeded them by an average of 9 times -- 24 times on one occasion.

Based on an average of the six individual measurements, fecal coliform bacteria concentrations in the creek at this site exceeded levels allowable in the STP discharge itself! The creek at this site was too unsanitary for swimming.

Turbidity exceeded drinking-water criteria six times out of the six measurements performed. The levels, however, were not substantially greater than those found at Site 01. Total suspended solids, on the other hand, were significantly greater than at Site 01. The 25 mg/l criterion was exceeded 62 percent of the time.

Un-ionized ammonia concentrations regularly surpassed the .016 mg/l limit. Surprisingly, of the nine exceedences documented from 14 samplings, nearly as many occurred in the winter as in the late summer under high temperature and pH conditions. This confirmed the previously discussed inefficient ammonia removal in the colder months.

Dissolved-oxygen levels at this site, when measured in December 1979, did not appear to suffer to a great degree from the oxygen demand of the STP discharge. Salmonid spawning criteria were always met. However, it is likely that problematic oxygen-depression occurs during high-temperature, low-streamflow conditions.

TABLE 33

Site No: 03 One-third mile downstream of Helena STP discharge

					Number of exceedences	
Parameter	Sample size	Minimum value	Mean	Maximum value	Public health, recreation and aesthetics	Protection of freshwater aquatic life
Streamflow (cfs)	15	19.2	42.5	63.4	--	--
Total phosphorus (mg/l)	16	.551	1.34	4.5	16	--
Total soluble inorganic nitrogen (mg/l)	16	1.04	3.14	8.31	16	--
Fecal coliform bacteria (orgs. per 100 ml)	6	10	859	3900	2	--
Turbidity (NTU)	6	6.1	7.1	9	6	--
Total suspended solids (mg/l)	8	16.6	33.2	48.2	--	at 25 5 at 80 0
Un-ionized ammonia (mg/l)	14	.002	.022	.050	--	9
Dissolved oxygen (mg/l)	5	9.96	10.63	12.17	--	0

Effects of sewage-treatment plant

Site 04

At Mountain View School

Streamflows consistently increased between Site 03 (just downstream from the STP discharge) and Site 04 at Mountain View School, a distance of about two miles. Mean streamflow, computed from all of the available measurements, was 28 percent greater at the Mountain View site. Individual measurements at both sites on the same day showed increases ranging from 2 to 49 percent. Sources of the increased flow are a tile-drain discharge, a spring, and probably some groundwater recharge in the area between the sites.

A result of the increased dilution was a decrease in phosphorus, nitrogen and total ammonia. However, the decreases were not sufficient to eliminate the bad effects of the STP discharge on the creek. Phosphorus and nitrogen concentrations continued to exceed recommended levels -- by 20 times and 7 times, respectively. The mean total ammonia concentrations were reduced from Site 03 to Site 04 (2.7 mg/l to 1.6 mg/l) as was the percentage of exceedences for the un-ionized ammonia criteria (64 percent versus 42 percent). However, the mean un-ionized ammonia concentration actually increased from Site 03 to Site 04. This can be explained by several relatively high un-ionized ammonia measurements for Site 04, taken on dates when measurements were not taken at Site 03. These values skewed the mean un-ionized ammonia concentration for Site 04 above that of Site 03. Also, Site 04 pH values and water temperatures were consistently higher than at Site 03. On several occasions, higher un-ionized ammonia concentrations were measured at Site 04 than at Site 03, despite lower total ammonia concentrations, because the quantity of un-ionized ammonia in solution is directly proportional to pH and temperature.

Fecal coliform bacteria counts were limited to two for this site. One of the two samples was collected in January 1980, on the same day that a sample was taken immediately below the STP discharge. Comparison of the two measurements showed a 550 percent reduction in organisms from Site 03 to Site 04, no doubt attributable to the near-freezing conditions then present in the Prickly Pear which would have killed many of the organisms. But the resultant concentration at Site 04 still exceeded body-contact criteria by 3 times. During warm months when swimming would be conceivable, the potential for pathogens would likely be much greater, assuming the sanitary quality of the STP discharge was no better than in January 1980.

Turbidity and total suspended solids values were not significantly different at Sites 03 and 04 when sampled on the same dates. However, the availability of data from two high-flow samplings in May 1979 and 1980 for Site 04 raised the mean and maximum turbidity and total suspended solids values above those for Site 03, because Site 03 was not sampled on those occasions. Dissolved oxygen, measured only once at Site 04, did not indicate a problem.

TABLE 34

Site No: 04 At Mountain View School two miles down from discharge

					Number of exceedences	
Parameter	Sample size	Minimum value	Mean	Maximum value	Public health, recreation and aesthetics	Protection of freshwater aquatic life
Streamflow (cfs)	17	24.9	54.5	153	--	--
Total phosphorus (mg/l)	24	.19	1.1	5.2	24	--
Total soluble inorganic nitrogen (mg/l)	18	.49	2.4	4.9	18	--
Fecal coliform bacteria (orgs. per 100 ml)	2	50	325	600	1	--
Turbidity (NTU)	11	1.1	9.3	29	10	--
Total suspended solids (mg/l)	13	5.7	38	86.6	--	at 25 9 at 80 2
Un-ionized ammonia (mg/l)	12	.001	.024	.078	--	5
Dissolved oxygen (mg/l)	1	10.92	10.92	10.92	--	0

Conclusions and recommendations

Conclusions

What happens, then, to the Prickly Pear after it meets Helena's sewage-treatment plant discharge? It's hard to tell exactly, because the impacts varied so much with the fluctuations of the streamflow and of the quality and quantity of the discharge. But a few conclusions can be drawn: Nutrients in the discharge aggravate the enrichment problem already existing in the creek -- but, fortunately, nuisance algae growth is limited by the lack of a good streambottom which, unfortunately, also limits the production of desirable organisms. The ammonia in the discharge is toxic to fish and aquatic life. There are more than enough coliforms in the creek below the discharge to make swimming an unsafe practice. The discharge pours suspended solids into the creek. And all of these pollutants still plague the creek at least two miles below the discharge.

This sounds grim enough, but the author feels that the Prickly Pear is polluted by the discharge to a much greater degree during the late summer than what was documented in this section. Irrigation withdrawals below East Helena leave little water in the stream channel to dilute the sewage effluent. Although data is lacking for such "worst-case" periods, it's likely that Prickly Pear Creek water at Sites 03 and 04 (below the discharge) more closely resembles the STP discharge itself than the water we measured at those sites during this study.

Such late-summer conditions definitely would be a limiting factor in the development and maintenance of a fishery and other beneficial water uses.

Recommendations

Abatement of the problems in lower Prickly Pear Creek that are associated with the Helena sewage-treatment plant discharge will depend upon:

- Improvement in the quality of the effluent being discharged
- Augmentation of the flows below East Helena

In order for regulatory agencies to require the Helena facility to upgrade effluent quality and to limit pollutants, the present E classification of the lower Prickly Pear will have to be upgraded. As discussed earlier, the E classification has been applied to this reach of the creek because of the late-summer dewatering. Therefore, rewatering to guarantee year-round instream flows would be the logical first step toward improvement of existing conditions (although there are other dewatered streams which have a higher-than-E classification already).

The City of Helena already has been informed of this possibility --

in fact, the possibility has been written into the treatment plant's newly-revised discharge permit, which states:

> "If Prickly Pear Creek is reclassified, the Department will have to determine the concentration of toxic materials (ammonia, chlorine, heavy metals) in Prickly Pear Creek below the confluence of the city's wastewater treatment plant. If concentrations exceed the recommended criteria and the source is the Helena plant, then the facility will have to upgrade to meet effluent limitations which will ensure water quality standards are not being violated."

If such upgrading (or switch to an alternative disposal system) becomes necessary if or when the Board of Health and Environmental Sciences upgrades the classification of the creek, a sequence of events could be put into motion: the Water Quality Bureau could order the plant to upgrade within a reasonable amount of time, the city could appeal the order to the Board of Health and Environmental Sciences, public notification and hearings could be held, etc.

The Montana Department of Fish, Wildlife and Parks is exploring ways to curb the dewatering problem (a detailed explanation is given in the next section, Part VI of this report). One alternative consists of purchasing Missouri River water from the Helena Valley Irrigation District and discharging it into the creek -- in the area where the creek first begins to go dry -- by way of an existing spillway on the district's canal. Another alternative was suggested by a Helena Valley rancher: give him water from the canal and he'd stop diverting Prickly Pear water just above the dewatered stretch (this alternative may require a minor change in the state water-rights laws to allow a landowner to trade a water right for an instream flow).

Such rewatering would tend to reduce pollutant concentrations and help to alleviate the toxic-ammonia situation at certain times of the year. However, year-round maintenance of a high-quality water which would allow the establishment of a fishery and other beneficial uses would require that the Helena STP practice some form of ammonia removal or an alternative method -- such as land application -- of disposing of the effluent.

Closer attention to disinfection, without exceeding chlorine limits, could reduce bacterial counts in the effluent -- allowing body-contact recreation in the creek.

Efforts aimed at the elimination of sediment sources in upper Prickly Pear Creek likely will result in an eventual improvement in the streambottom of the lower Prickly Pear. If that happens, nitrogen and phosphorus levels in the effluent may have to be reduced to prevent nuisance growths of aquatic plants.

And finally, suspended-solids levels in the effluent, if kept within discharge-permit limitations, should be of little threat to the Prickly Pear if adequate flows are maintained and upstream sediment sources are minimized.

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Part VI

Possibilities for “rewatering” the Prickly Pear

Department of Fish, Wildlife and Parks

July 1981

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Introduction

Prickly Pear Creek has been a source of water for agriculture for more than a century; and, like many streams east of the Continental Divide, demand for irrigation water often exceeds supply. Consequently, during the peak water-demand months of July through September, the Prickly Pear is severely, if not completely, dewatered.

Most of the agricultural water usage occurs in the broad, flat valley north of East Helena, but nearly all of the points of diversion lie from East Helena south to Clancy. The last major diversion as the water moves downstream -- at the Don Burnham Ranch just north of East Helena -- often thoroughly depletes the Prickly Pear for at least a two-mile stretch, essentially severing the stream's connection with the Missouri River. The distance from this last point of diversion to Lake Helena -- an arm of Hauser Reservoir, which is part of the Missouri system -- is approximately 10 stream miles.

Other sections of this report (Parts I, II, and V) have identified the dewatering as one of the major problems to be overcome in the restoration of the Prickly Pear.

The future of water use

When the records of the Prickly Pear water users are reviewed, it becomes apparent that the creek is overappropriated. In fact, all of the "paper rights" on the stream total up to more than three times its average summer flow. So, except for years like 1975 which had an unusually wet summer, there is not enough water in the creek at present withdrawal rates to supply all of the requests for irrigation water -- leaving little wonder that the creek dries up!

The hope for re-watering Prickly Pear Creek, then, would seem quite bleak unless the following factors are considered:

- The number of irrigable acres within the Prickly Pear Basin is decreasing as more land around Helena becomes urbanized.
- More efficient means of spreading irrigation water -- such as sprinkler systems -- are coming into use, meaning water right holders will not have to withdraw as much water to fulfill their needs.
- Water rights will be adjudicated on the Prickly Pear, as required under the law established by Senate Bill 76, making it likely that certain users will be found to be diverting more water than they are actually putting to a beneficial use.

In the long run, revamped management of water and a reduction of agricultural needs will lead to more water being left in Prickly Pear Creek. Meanwhile, what else could be done to enhance the creek's flow?

A proposal

The Helena Valley Canal crosses Prickly Pear Creek about one-half mile north of East Helena, very near Don Burnham's lowermost point of diversion. Ron Schofield, manager of the canal system, said that water from the canal could possibly be diverted into the Prickly Pear on an "as available" basis. This means that after all of the agricultural demands on the canal are met, excess water could be purchased for an instream use. And during most years, some water should be available. In the future, probably even more canal water will be available because of increased urbanization and irrigation efficiency.

Therefore, the possibility exists for a state agency, like the Department of Fish, Wildlife and Parks, to purchase water "as available" from the Helena Valley Canal for instream (fish and wildlife) usage. It must be remembered, however, that all state agencies are now trying to reduce, rather than expand, expenditures on new projects (perhaps leaving the door open for some citizens' organization to arrange a water purchase with private donations).

There are three major benefits to be gained by re-watering the Prickly Pear:

- Enhancement of sport fishing in a stream that is very close to a major Montana city. With ever-increasing gasoline and other transportation costs, more and more people will be turning to fish and wildlife resources closer to cities and towns.

- Enhancement of rainbow- and brown-trout spawning. With significant progress being made towards removing the fish barrier at the Asarco dam and the acid mine waste from Spring Creek, Prickly Pear Creek could become a a major spawning tributary for the Missouri River system if the missing water link from East Helena to Lake Helena were restored.*

- Upgrading of the creek from an E classification to a B-1 classification, which could lead to the clean-up of the Helena sewage-treatment plant discharge. Such a clean-up also would facilitate fish passage.

With these benefits in mind, the Department of Fish, Wildlife and

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*The Department of Fish, Wildlife and Parks prefers enhancement of wild-fish production to the planting of hatchery fish, since wild trout, as a rule, are hardier and longer-lived, resulting in the larger-sized fish that are preferred by most anglers.

Parks may be able to justify the purchase of water from the Helena Valley Canal during the summer months, if it is available. This purchase could become more justifiable if wild-fish recruitment from Prickly Pear Creek were to become significant enough to allow a reduction in the number of hatchery fish needed to be planted into Hauser Reservoir. At the present cost of hatchery fish -- ranging from $10,000 to $20,000 annually for this reservoir -- it would not take too large a reduction in fish plants to pay for the rewatering of the Prickly Pear. The annual water purchase could simply become a transfer of department expenditures rather than the initiation of new project funding.

Another proposal

In 1980, rancher Don Burnham suggested that he might be willing to come up with a kind of transfer that would help rewater the Prickly Pear. "Give me water out of the Helena Valley Canal," he said, "and I'll stop diverting creek water at my lowermost diversion point." The Department of Fish, Wildlife and Parks, the Water Quality Bureau, and the state Department of Natural Resources and Conservation took him up on his suggestion and drafted a bill to help smooth such a water switch. The bill -- given to a local legislator for introduction in the 1981 Legislature -- would amend state water-rights laws to allow landowners to donate their water right for an instream right without having that right snatched up by junior water users. The bill was never introduced -- either because the legislator's staff needed more time to research and polish it or because it just got overwhelmed in the avalanche of bills in that session.

Summary

In any case, both rewatering possibilities will continue to be pursued by the state agencies. More information will be gathered about the availability of irrigation water -- from sources other than the Prickly Pear -- in the Helena Valley. And more landowners may be approached about the possibility of water trade-offs.

Whatever the outcome, the rewatering of the Prickly Pear Creek below East Helena must remain one of the major goals of any restoration project.

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